

**HIGH VOLTAGE ENGINEERING**



**HVI-539M2  
INSTRUCTION  
MANUAL**

**The Model KN-4000  
Vertical Accelerator**

# **RADIATION WARNINGS AND RECOMMENDATIONS**

## **INSTRUCTION SHEET HVI-1170M1**

(REPLACES HVI-1080, HVI-1090 AND HVI-1170)



### **WARNING**

**Particle Accelerators Produce Ionizing Radiation Capable of Causing Serious and Possibly Fatal Injury to Personnel.**

1. Particle accelerators produce dangerous radiations against which personnel must be protected. The amount, location and type of such radiation depend not only on the particle accelerator itself, but also upon its installation environment and other operating conditions. The Owner, having exclusive control over the operation of the accelerator and its surroundings, must provide adequate shielding and protective systems so as to prevent injury to persons or damage to property and to ensure that operation of and access to the particle accelerator will be only by expert and authorized personnel.
2. Federal and State laws require the Owner to provide a safe facility in which the machine is to operate. The Owner should familiarize himself with applicable requirements and maintain his entire facility in conformity with them on a continuous basis. Applicable Federal laws and authoritative recommendations include:
  - 2.1 Federal Occupational Safety and Health Act of 1970 (Public Law 91-596) and the regulations promulgated under that Act, particularly 29 CFR 1910.
  - 2.2 American National Standards Institute and U.S. National Bureau of Standards:
    - a. ANSI-N43.1-1969 - Radiological Safety in the Design and Operation of Particle Accelerators (NBS Handbook 107).
    - b. ANSI-N543-1974 - General Safety Standard for Installations Using Non-Medical X-Ray and Sealed Gamma-Ray Sources, Energies up to 10 MeV (NBS Handbook 114).
  - 2.3 Reports of the National Council on Radiation Protection and Measurements, including:
    - a. NCRP-38 - Protection Against Neutron Radiation (1971).
    - b. NCRP-39 - Basic Radiation Protection Criteria (1971).
    - c. NCRP-49 - Structural Shielding Design and Evaluation for Medical Use of X-Rays and Gamma Rays of Energies up to 10 MeV (1976).
3. Particular considerations associated with the above laws and recommendations relating to Van de Graaff electrostatic, and ICT<sup>®</sup> insulating core transformer, type accelerators include:
  - 3.1 Adequate radiation shielding must be provided to entirely surround the particle accelerator.
  - 3.2 Personnel must be excluded from the radiation area when the particle accelerator is, or is capable of, producing dangerous radiation.
  - 3.3 Every entrance or access to the radiation area should be interlocked in such a way that if the interlock is disturbed, the charging belt drivemotor is stopped in the case of a Van de Graaff accelerator, or power is removed from the power supply in the case of an ICT<sup>®</sup> accelerator.
  - 3.4 Never, under any circumstances, should entry into the radiation area be made when a cathode-ray (foil) window is in position on an accelerator and the charging belt drivemotor is running in the case of a Van de Graaff accelerator, or when an accelerator is connected to an ICT<sup>®</sup> power supply with control power on.
  - 3.5 Radiation areas should be so designed as to preclude any necessity to enter the area while an accelerator is, or is capable of, being operated. Redundant safety systems should be provided. Safety interlocks and circuitry should be arranged in completely separate systems, and they should be made inaccessible to operating personnel. Entry into radiation areas for servicing purposes should be strictly controlled, and should occur only under the personal supervision of the responsible safety officer.
  - 3.6 Although the controls of an energized accelerator may be set for zero voltage and beam, an accelerating voltage and beam may nevertheless be present; therefore, radiation can be produced any time the charging belt is being driven on a Van de Graaff accelerator with an ungrounded high voltage terminal, or when an ICT<sup>®</sup> accelerator is connected to a power supply with control power on.
  - 3.7 The type of radiation from some accelerators may be quickly or easily changed. It must be recognized that shielding and protective systems which may be safe under one condition may be extremely hazardous under another and the Owner must provide for all foreseeable operation of the accelerator.
  - 3.8 Some accelerators may use or produce toxic substances, and may produce induced or airborne radioactivity. The Owner must determine the extent to which the accelerator facility may require special ventilation and other apparatus and procedures in the handling and removal of such substances and must provide these.
  - 3.9 Operating procedures should always require conscious and complete inspection of the radiation area to ensure no persons are present before the equipment is energized and conscious and complete shutdown of the accelerator at the accelerator control console before entry to the radiation area is attempted.



**HIGH VOLTAGE ENGINEERING CORPORATION**

BURLINGTON, MASSACHUSETTS 01803, U.S.A.

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## REFERENCES

<u>Number</u>		<u>HVE Designation</u>
1	THE ION SOURCE ASSEMBLY, C-K-SO-8	HVI-1084M1
2	THE CORONA POINT ASSEMBLY	HVI-1056M1
3	THE VOLTAGE STABILIZER	HVI-1169M1
4	THE DEW POINT INDICATOR	HVI-1055
5	THE 50 kV HIGH VOLTAGE POWER SUPPLY	HVI-486
6	DRIVEMOTOR AND ALTERNATOR DISASSEMBLY INSTRUCTIONS	HVI-1031M3
7	THE THERMO-MECHANICAL LEAK	HVI-1044
8	PALLADIUM LEAK INSTRUCTIONS	HVI-1013M2
9	MAINTENANCE OF THE PENNING GAUGE	HVI-1045M2
10	THE DRIVEMOTOR TEMPERATURE CONTROL AND METERING ASSEMBLY	HVI-1087
11	BELT CHARGE CONTROL ASSEMBLY	HVI-1093M1

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## SECTION I

### INTRODUCTION

#### 1. GENERAL

The Model KN-4000 Van de Graaff Accelerator, manufactured by High Voltage Engineering Corporation, is a precision 4 MeV, high intensity source of positive ions. The accelerator produces an accelerated beam of ions which is intense, homogeneous, of known energy and of predictable direction and dimension. The beam is also stable and controllable over a wide range of energies.

#### 2. ACCELERATING VOLTAGE

A Van de Graaff belt type, electrostatic generator is used to develop accelerating voltages up to 4 MV. Basically, the operation of the generator is as follows: electrons are constantly removed from the high voltage terminal and transported to ground. The terminal is positively charged to any desired level by this constant removal of electrons. A uniform voltage gradient, developed along the accelerator tube, accelerates the positive ions to energies up to 4 MeV. This gradient is developed by the column current flowing through a series-string of resistors. The operation of each of the generator components is described in the Maintenance Section. (Refer to Figure 1.)

#### 3. ACCELERATION PATH

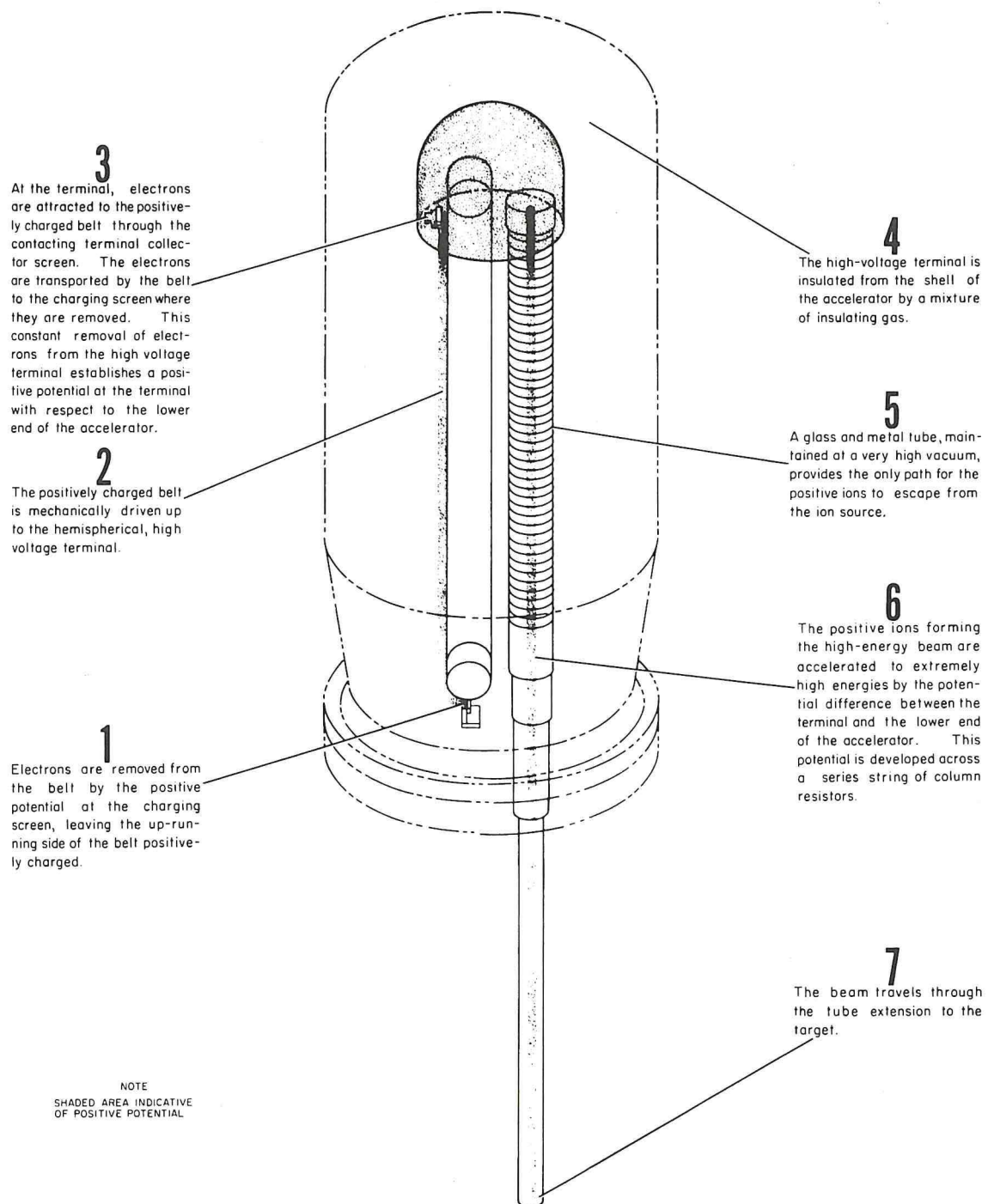
The acceleration path for the positive ion beam is provided internally, by a highly evacuated accelerator tube, and externally, by a similarly evacuated tube extension assembly.

#### 4. POSITIVE ION SOURCE

The positive ion source consists of: a source bottle, a gas supply, and the terminal electronics necessary for operation. In brief, gas (e.g., hydrogen) is introduced into a source bottle and is ionized by rf energy. The resulting plasma is magnetically concentrated at the exit canal of the source bottle. Positive ions are repelled, through the exit canal, into the acceleration path by a potential applied to the anode (i.e., probe) of the source bottle. Further acceleration is provided by the voltage gradient developed along the column.

#### 5. VACUUM SYSTEM

The vacuum system provides a means of maintaining the accelerator tube and tube extension under a high vacuum at all times, thus minimizing collisions between accelerated particles and gas molecules within the accelerator tube system. In the event of vacuum system failure, a relay operates to shut down the generator. The vacuum system consists of: an oil diffusion pump with water cooled chevron baffle, a vane type motor-driven fore pump, a vacuum control console, a Penning gauge, and various operating and protective circuits and devices.



**FIGURE 1. PRINCIPLES OF OPERATION**

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## 6. WATER COOLING SYSTEM

The system includes a water chiller supplying cooling water for the pressure tank. Vacuum system, targets, viewers, focusing rings, and analyzing magnets (if used) are cooled directly by city water.

## 7. CONTROL SYSTEMS

### a. Vacuum System Controls

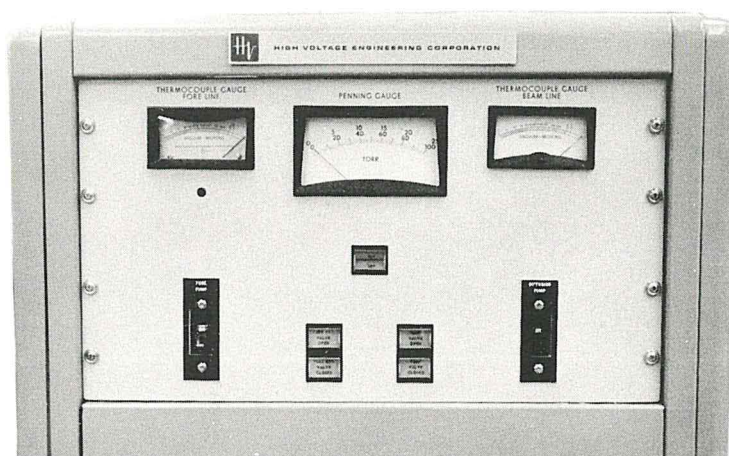
All the vacuum system controls are conveniently located at the vacuum control console. Figure 2, page 4, illustrates the console and identifies the functions of each control.

### b. Accelerator Operating Controls

All the accelerator operating controls are conveniently located on front panels mounted on the control console. Figure 3, page 5, illustrates the panel and identifies the function of each control.

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VACUUM CONTROL CABINET



VACUUM CONTROL PANEL

FIGURE 2. VACUUM SYSTEM CONTROLS

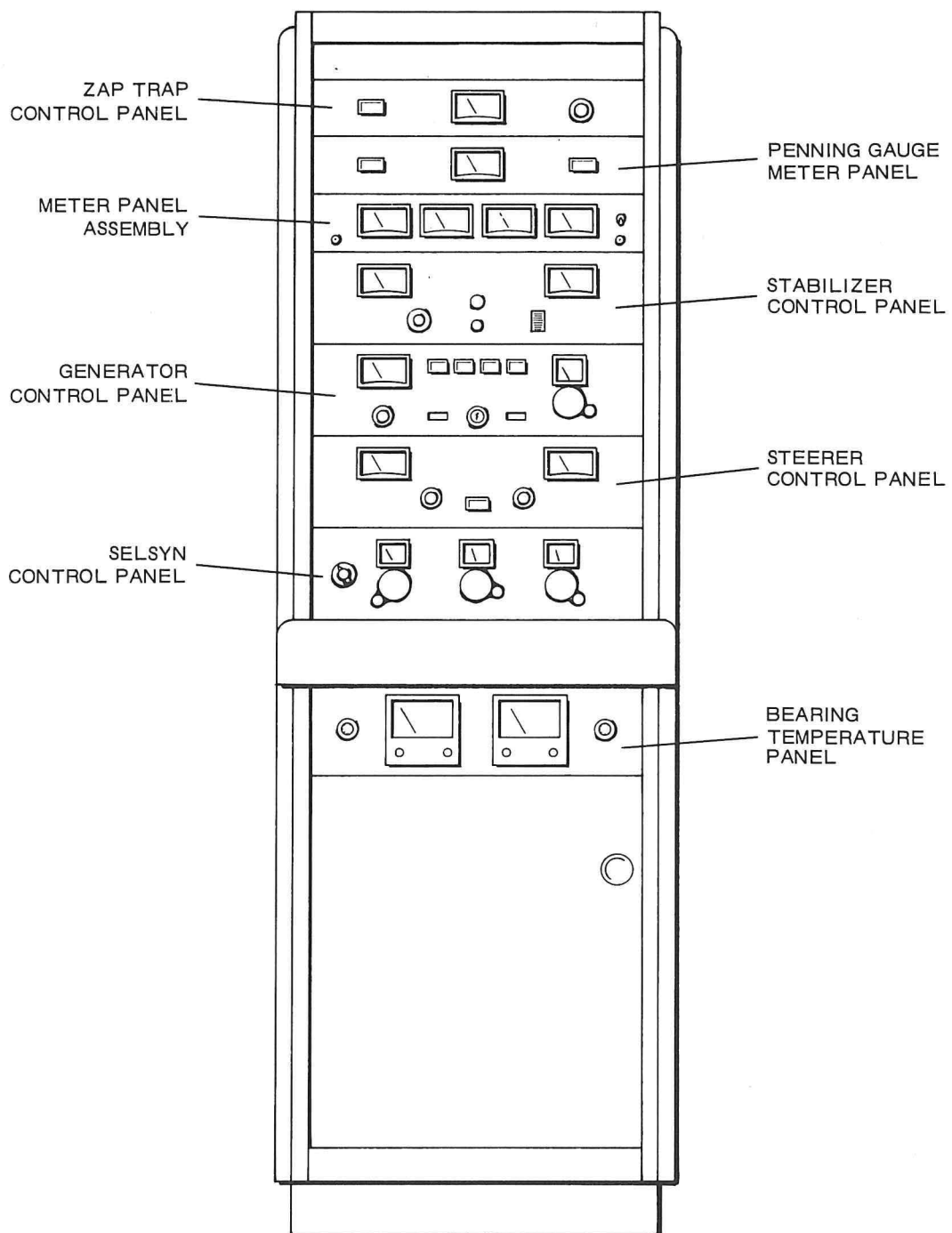


FIGURE 3. ACCELERATOR CONTROLS

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## SECTION II OPERATION

### 1. GENERAL

The preceding Section of this instruction manual familiarizes the operator with the accelerator. This Section will deal with the use of the controls for accelerating positive ions to energies of up to 4 MeV.

#### — WARNING —

DO NOT PERMIT PERSONNEL IN THE  
ACCELERATOR OR TARGET ROOMS  
WHILE THE ACCELERATOR DRIVE-  
MOTOR IS RUNNING. (SEE HVI-1170M1,  
FIRST PAGE, ADDENDED.)

### 2. OPERATOR'S LOG

In the event of trouble, an accurately kept operator's log will prove extremely useful to the maintenance man repairing the equipment. An example of the recommended log form is shown in Figure 4, page 7.

### 3. NORMAL OPERATION

#### a. Preliminary Steps

- (1) Check and record the tank pressure. The accelerator should not be operated at a tank pressure below 275 psig, N<sub>2</sub>:CO<sub>2</sub> 80:20 65 psig for SF<sub>6</sub>. If the pressure level is low, refer to paragraph a., page 11, of the Maintenance Section.
- (2) Check the Power Distribution Panel for proper circuit-breaker settings.
- (3) Set the Lucite selector rod on the Belt-Charge Control Unit to INTERNAL.
- (4) At the vacuum control console:
  - (a) Check that the diffusion pump and fore pump are energized and that their respective indicators light.
  - (b) Check and record the vacuum system VACUUM meter reading.



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NOTE: The accelerator tube and tube extension must be kept evacuated at all times during operation. The accelerator cannot be operated unless a good vacuum is indicated.

- (5) Compare the operating control console VACUUM reading with the reading obtained at the vacuum control cabinet. All vacuum monitoring is performed at the control console once the accelerator is in operation. Note that the VACUUM meter at the accelerator control console has two independent scales (HI and LO) and does not require interpolation.
- (6) Select the desired ion source operating gas.

b. Positive Operation

- (1) Evacuate all personnel from the target and the accelerator rooms.
- (2) Set the POS/NEG switch at the rear of the control console to the desired operating mode.
  - (a) POS - for positive operation
  - (b) NEG - for negative operation
- (3) Turn in the control power with the key switch.
- (4) Rotate all controls fully CCW.
- (5) Set the corona stabilizer ON/OFF switch to OFF.
- (6) Press the DRIVEMOTOR ON switch.

NOTE: The drivemotor will not start if a poor vacuum exists, if the cooling-water flow is insufficient, or if the tank temperature is above 100 °F.

- (7) Actuate the BELT-CHARGE ON switch.
- (8) Condition the acceleration tube as described in paragraph (3), page 49.
- (9) Turn the CHARGING control slowly CW until the VOLTAGE meter indicates the desired terminal voltage. If the desired terminal

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voltage cannot be obtained, slowly increase the BELT CHARGE ADJUST control until the voltage is obtainable.

- (10) At the desired terminal voltage, the corona points are to be adjusted (with the INCREASE/DECREASE function switches) for a CORONA LOAD meter indication of approximately 150  $\mu$ A. Record all readings in the Operator's Log.
- (11) Advance the GAS control in order to "strike the source". Monitor the VACUUM meter. A deteriorating vacuum situation indicates an excessive gas flow which could damage the source.

NOTE: Throughout this manual, an excessive gas flow is referred to as "flooding the source".

- (a) If the source should "flood", decrease the GAS control unit until the vacuum returns to normal.
- (b) Increase or decrease the BEAM control to obtain the desired beam current. Adjust the GAS control and reset the BEAM control as required.

NOTE: If the source is inoperative, refer to the source tuning instructions, maintenance section (HVI-1084M1).

- (12) As the BEAM control is increased, the terminal voltage will start to drop due to the additional load applied to the belt charge circuit. Increase the CHARGING control to maintain initial voltage and corona load settings. Adjust the FOCUS control for minimum pick-up on the focus ring.
- (13) For information on the stabilization network, refer to Stabilizer Instruction Book.
- (14) Record all meter readings in the log book.

NOTE: Periodically compare the meter readings in the log. A sudden change in any of the values is usually indicative of component failure. For example, the relationship between column current and terminal voltage, once established, should remain fairly constant. A sudden change in this relationship, although the charging current remains constant, could indicate failure in the column resistor circuit or in the generating voltmeter circuit.

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c. Shutdown

- (1) Simultaneously decrease the BEAM and the CHARGING controls fully CCW.
- (2) Decrease the GAS and FOCUS controls to zero.
- (3) Switch the BELT-CHARGE OFF.
- (4) Switch the DRIVEMOTOR OFF.
- (5) Turn off the control power with the key switch.

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## SECTION III MAINTENANCE

### 1. GENERAL INFORMATION

HVE provides a complete set of electrical and mechanical drawings, parts list and vendor's data with each accelerator system. These should be used as the prime source of maintenance information.

#### WARNINGS

- OBSERVE ALL HIGH VOLTAGE AND RADIATION PRECAUTIONS. (SEE HVI-1170M1, FIRST PAGE, ADDENDED.)
- DO NOT REMAIN IN THE ACCELERATOR OR TARGET ROOMS WHEN THE DRIVEMOTOR IS ENERGIZED.
- DO NOT PERFORM MAINTENANCE ON AN OPENED ACCELERATOR UNTIL THE HIGH VOLTAGE TERMINAL HAS BEEN GROUNDED TO THE ACCELERATOR BASE PLATE.

#### a. Records

Two types of records should be kept: the Operator's Log which is described in the Operation Section, and a service log of accelerator components as shown in Figure 5, page 12. A log of this type will show what maintenance has been accomplished, the condition of components removed from service, and compliance with the recommended schedules for lubrication and preventive maintenance. Such records are of benefit in the following areas:

- (1) Assisting maintenance personnel to diagnose problems.
- (2) Calling attention to recurrent problems.
- (3) Providing a basis for analysis and reports of equipment operation.

#### b. Cleaning

Proper cleaning of the accelerator system should be performed on a regularly scheduled basis. The recommended cleaning procedures are described in the following paragraphs.

#### WARNINGS

- BEWARE OF HIGH VOLTAGE WHEN CLEANING THE ACCELERATOR. ALWAYS OBSERVE STANDARD SAFETY PRECAUTIONS.
- CONTROL CABINETS MUST NEVER BE OPENED BY UNTRAINED PERSONNEL. CONTACT WITH HIGH VOLTAGE CAN RESULT IN SERIOUS INJURY.



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- (1) Clean each chassis in the control console, and check for worn, dented, or broken component parts. This procedure should be performed by QUALIFIED MAINTENANCE PERSONNEL ONLY.
  - (2) Clean the accelerator whenever it is opened for maintenance. Use a hand blower that provides air which is free of condensation, and a lintless wiper.

— CAUTIONS —

- NEVER BLOW OUT THE ACCELERATOR TUBE AND TUBE EXTENSION. FOREIGN MATTER INTRODUCED DURING THIS PROCESS CAN CAUSE SERIOUS TROUBLE.
- USE ONLY LINTLESS CLOTH WHEN CLEANING THE ACCELERATOR. EQUIPMENT MALFUNCTION CAN RESULT FROM LINT.

- (3) Sweep, dust, and clean the accelerator and the target rooms. When sweeping, use a cleaning compound that will not leave a residue.
- (4) When wiping the surfaces of the accelerator tube or tube extension, use a lintless wiper. (Do not use solvents on the tube seals.)
- (5) Periodically check and clean the air and water filters used in the system.

c. Lubricating

The major accelerator components requiring lubrication are listed in the lubrication chart contained on Table 1, page 15, and illustrated in Figure 6, page 14. Consult the references to obtain the recommended lubrication procedure.

d. Sparking

There are three types of sparking that may occur because of the very high potentials used in the accelerator. These can be identified by their sound and their effects on the meter readings.

- (1) Tank Spark -- This is a loud "clang" that sounds as though the tank or the terminal has been hit with a hammer. This sound is caused by sparking between the terminal and the grounded tank. Tank sparking will cause the terminal VOLTAGE meter and the COLUMN CURRENT meter to drop toward zero. The VACUUM indication will normally remain constant and the TOTAL CHARGE meter (if stabilized) will indicate a large increase in charging current.
- (2) Column or Belt Sparks -- This is a series of sparks along the column that are not as loud as tank sparks and are sometimes barely audible. This type of spark causes the VACUUM meter indication to increase slightly and recover quickly, and also causes the COLUMN CURRENT meter indication to increase.

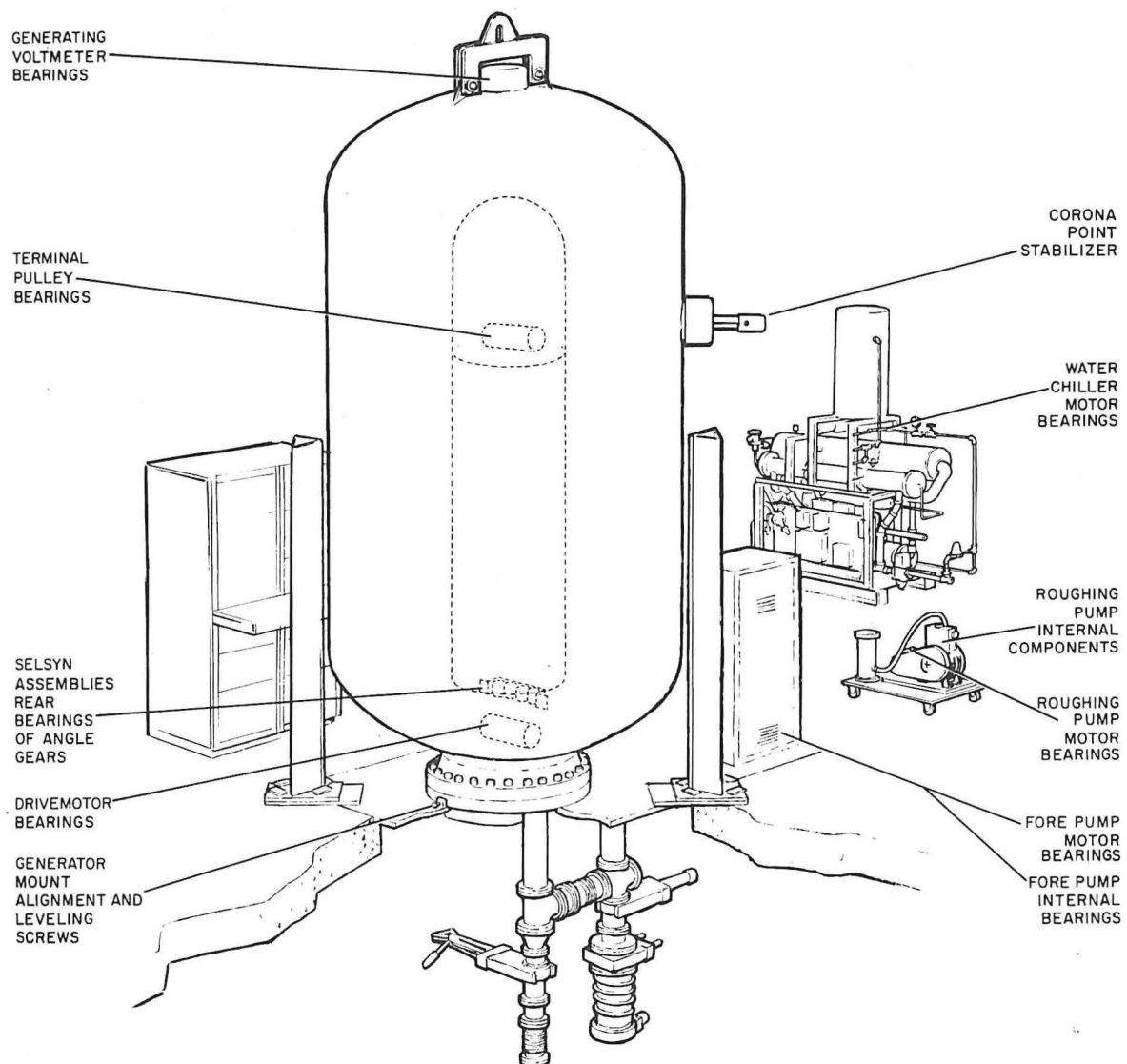


FIGURE 6. ACCELERATOR LUBRICATION AREAS

TABLE 1. LUBRICATION CHART

Component	Location	Part Lubricated	Lubricant	Lube Sched.	Procedure
Drivemotor	Tank Base	Bearings	Shell Alvania No. 2	1,000 hours	Replace grease. (3/4 oz.)
Motor, Fore Pump	Vacuum Console	Bearings	SAE 10	Bi-monthly	Lift spring cap, apply a few drops of oil to bearings.
Pump, Fore	Vacuum Console	Internal Components	Welch Duoseal Pump Oil	Monthly Annual	Replenish to window level. Replace (1 pint).
Mount, Generator	Mount Base	Alignment and Leveling Screws	Shell APL	Annual	Spread light film of grease on threads.
Motor, Roughing Pump	Portable	Bearings	SAE 10	Bi-monthly	Lift spring cap, apply a few drops of oil to bearings.
Pump, Roughing	Portable	Internal Components	Welch Duoseal Pump Oil	Monthly Annual	Replenish to window level. Replace (1 pint).
Pulley, Terminal	Terminal	Bearings	Shell Alvania No. 2	1,000 hours	Replace grease. (3/4 oz.)
Motor, Corona Stabilizer	Tank Shell	None			Sealed bearings. Replace as necessary.
Voltmeter Generating	Tank Shell	None			Sealed bearings. Replace as necessary.
Water Chiller	Water Chiller	Bearings			As directed by manufacturer's bulletin.

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- (3) Tube sparking is within the tube. This is very much like a column spark but is a little sharper in sound. The changes in meter readings during the sparking can be used to differentiate between the two sparkings. Tube sparking will cause the VACUUM meter indication to increase toward an off-scale position. Recovery is usually slow.

e. Troubleshooting

Consult the accelerator system diagrams, the Troubleshooting Chart on page 19, and the appropriate paragraph (refer to the Table of Contents) to obtain the require troubleshooting information.

- (1) Analysis of Trouble -- When trouble is indicated: analyze the operator's reports and the service log, check any circuit-breakers and/or pilot lamps that may be involved, and check any circuit adjustments which may be required.
- (2) Check-Run -- If necessary, perform a check-run of the equipment, based on the operating procedure, and observe the reactions of the meters.

— WARNINGS —

- EXERCISE PRECAUTIONS AGAINST HIGH VOLTAGE AND RADIATION. SERVICING SHOULD BE PERFORMED BY TEAMS OF TWO OR MORE MEN AT ALL TIMES.
- DE-ENERGIZE THE CIRCUIT AND DISCHARGE ALL CAPACITORS BEFORE MEASURING DC RESISTANCES TO GROUND.
- DO NOT USE FLEXIBLE LEADS WHEN MEASURING VOLTAGE IN EXCESS OF 1000 VOLTS. SEE SPECIAL INSTRUCTIONS, PARAGRAPH (6) BELOW, BEFORE MEASURING HIGH VOLTAGES.

- (3) Measuring High Voltages -- Plant safety instructions and practices should be followed carefully when high voltages are being measured. In the absence of specific instructions, the following procedure is suggested.
  - (a) De-energize and discharge the circuit to be measured.
  - (b) Use a voltmeter and multiplier circuit that has at least twice the voltage range of the circuit to be measured.
  - (c) Ground the cases of the voltmeter and multipliers. If this is impractical, place the voltmeter and multiplier on suitable

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insulation and erect barriers to prevent accidental contact and grounds.

- (d) Connect the voltmeter and the circuit to be measured with single conductor leads insulated from each other and from ground.
  - (e) Energize the circuit to the desired level.
  - (f) Observe the voltmeter indication.
  - (g) De-energize and discharge the circuit.
  - (h) Remove the meter and restore the circuit.
- (4) Tracing Electrical Circuits -- Unless the evidence clearly localizes trouble within a component, the next step in troubleshooting is to trace the suspected electrical circuit.
- (a) Typical circuit troubles are: poor contacts, short circuits, grounds, broken conductors, or joints.

**NOTE:** The belt charge high voltage lead through the generator base is special, single conductor, coaxial cable. This cable must be replaced by identical cable (HVE Part No. P-5956).

- (b) Dead-circuit tracing can be performed with an ohmmeter, bell, or a buzzer. Always discharge capacitors before tracing a dead circuit. Dead-circuit tracing is used to check continuity of wiring, joints, and back contacts of relays.

— CAUTION —

DO NOT DE-ENERGIZE THE VACUUM PUMP CIRCUIT UNLESS CERTAIN THAT THE CIRCUIT IS CAUSING TROUBLE. IF IT IS NECESSARY TO OPEN THE CIRCUIT, FIRST CLOSE THE GATE VALVES IN THE ACCELERATOR TUBE EXTENSION.

- (c) Live circuit tracing of circuits 208 volts or less is done with a voltmeter set at least to the 300-volt scale. The few circuits in this equipment that are above 208 volts are carefully shielded.

TABLE 2. THE REFERENCE DESIGNATION SYSTEM

The reference designation system provides a means of identifying the type of component, its main and substation location within the system, and the component serial number. A typical reference designation $\mu a1E03$ is shown below. Each section is broken down to show the make-up of the reference designation system.			
TYPE OF COMPONENT	MAIN STATION	SUB-STATION	COMPONENT SERIAL NO.
$\mu A$ (Microammeter)	1 (Control Cabinet)	E (Positive Ion Control Panel)	03 (Meter Number 3)
TYPE OF COMPONENT			
A -- Ammeter	L -- Inductor	RX -- Non-Thermionic Rectifier	
BA -- Battery	M -- Motor	S -- Switch	
C -- Capacitor	MA -- Milliammeter	SS -- Selsyn Unit	
CB -- Circuit Breaker	$\mu A$ -- Microammeter	SV -- Solenoid Valve	
F -- Fuse	NE -- Neon Lamp	T -- Transformer	
G -- Generator, Alternator	PB -- Pushbutton	TD -- Time Delay Relay	
H -- Heater Element	PL -- Pilot Lamp	TT -- Timeter (Total Time)	
J -- Jack	R -- Resistor	V -- Electron Tube	
P -- Plug	RL -- Relay	VM -- Voltmeter	
MAIN STATIONS			
1 Control Cabinet	5 High Voltage Terminal		
2 Power Distribution Panel	6 Vacuum and Cooling Water		
3 Local Control	7 Accelerator Tube Extension		
4 Generator	8 Belt Charge System (External)		
SUBSTATIONS - Only major substations, associated with the basic control cabinet are shown. For a complete station list, refer to the system drawings supplied with the equipment.			
D -- Vacuum Meter Panel	F -- Stabilizer Control Panel		
B -- Generator Control Panel	G -- Beam Steerer Control Panel		
C -- Selsyn Control Panel	H -- Zap Trap Control Panel		

TABLE 3. GENERAL TROUBLESHOOTING CHART

TROUBLE	PROBABLE CAUSE	REMEDY
VOLTAGE Meter shows a zero indication while a check of the COLUMN CURRENT Meter shows a normal reading.	a. Generating Voltmeter is inoperative.	a. Check the generating voltmeter components. Check connectors and circuit wiring. Replace components as necessary.
	b. Stabilizer control panel inoperative.	b. Refer to Stabilizer Instruction Manual.
	c. Defective circuit wiring.	c. Check all circuit wiring for short or open conditions. Replace as necessary.
VOLTAGE Meter gives a fluctuating indication.	a. Tank or tube sparking, caused by one or more of the following conditions:	a. To correct sparking, proceed as follows:
	(1) Moisture in the pressure tank gas mixture. Gas dew point should not be higher than $-55^{\circ}\text{F}$ . An optimum gas dew point would be $-60^{\circ}\text{F}$ .	(1) Dry out or replace the pressure tank gas supply.
	(2) Low carbon dioxide ( $\text{CO}_2$ ) content in pressure tank gas mixture. The $\text{CO}_2$ content should be at least 20%.	(2) Check $\text{CO}_2$ content in pressure tank. Add gas if necessary.
	(3) Tank gas pressure is low.	(3) Condition the accelerator tube.
	(4) Accelerator tube requires voltage conditioning.	(4) Add gas to increase the tank pressure.

TABLE 3. GENERAL TROUBLESHOOTING CHART (Continued)

TROUBLE	PROBABLE CAUSE	REMEDY
BEAM CURRENT Meter registers a zero indication.	a. Ion source not lit. This situation could be caused by one or more of the following conditions:	a. Repair the ion source as follows:
	(1) Faulty source bottle.	(1) Check ion source bottle for cracks or breaks. Replace if visible evidence of damage exists.
	(2) Faulty alternator.	(2) Check alternator output. Repair or replace alternator if necessary.
	(3) Faulty rf exciter.	(3) Check the rf exciter by following the tuning procedure described in Reference No. 1, addendum. Repair or replace defective components as necessary.
	(4) Faulty probe power supply.	(4) Check the probe power supply output between (+) and the high voltage terminal (ground). Repair or replace defective components as necessary to effect repair.
	(5) Faulty Focus power supply.	(5) Check the focus power supply output between (-) and the high voltage terminal (+). The output can be varied by adjusting the FOCUS ADJUST control. Be careful not to exceed an output of 5 kV while the power supply is at atmospheric pressure. Repair or replace defective components as necessary to effect repair.

TABLE 3. GENERAL TROUBLESHOOTING CHART

TROUBLE	PROBABLE CAUSE	REMEDY
BEAM CURRENT Meter (Continued).	(6) Faulty gas leaks or controls.	(6) Check the gas leaks, cylinder and gas control circuits in use. Repair or replace defective components as necessary to effect repair.
	b. Meters NEGATIVE-POSITIVE Switch is faulty.	b. Check switch for a short open condition. Replace if necessary.
	c. Faulty meter circuit wiring or components.	c. Check all wiring and components associated with meter. Repair or replace as necessary.
TOTAL CHARGE Meter registers a zero indication.	a. The belt charge circuit breakers or charge control circuit breakers are faulty.	a. Check circuit breakers for open conditions. Replace fuse if necessary.
	b. Faulty control circuit wiring or components.	b. Check the following control circuit components. Replace if necessary.
		(1) BELT CHARGE switches.
		(2) Bypass switch and interlock relay (if used).
		(3) Belt charge relay.
		(4) BELT CHARGE variable transformer.
		(5) ON/OFF switch (located on the power supply).
		(6) Constant voltage transformer.
		(7) BELT CHARGE variable transformer.

TABLE 3. GENERAL TROUBLESHOOTING CHART (Continued)

TROUBLE	PROBABLE CAUSE	REMEDY
		(8) All associated circuit wiring.
	c. Faulty power supply	c. Check the power supply. Replace defective components as necessary.
	d. Faulty control unit.	d. Check the control unit using standard troubleshooting procedures. Repair or replace defective components as necessary.
	e. METERS NEGATIVE-POSITIVE Switch is faulty.	e. Check switch for an open or short condition. Replace switch if necessary.
TOTAL CHARGE Meter registers but column current and voltage meters read low or zero.	a. Breakdown of feedthru bushings in generator base plate.	a. Check feedthru bushings in generator base plate for visual evidence of breakdown. Replace any defective bushings.
	b. Up-charge spray screen discharging to drive pulley.	b. Check the up-charge spray screen to determine if any of its points are close enough to the drive pulley to cause shorting. Check the charging belt for proper alignment and tracking.
COLUMN CURRENT Meter displays a zero indication.	a. Faulty circuit wiring.	a. Check all circuit wiring. Replace as necessary.
	b. METERS NEGATIVE-POSITIVE Switch is faulty.	b. Check for open or short conditions. Replace switch if necessary.

TABLE 3. GENERAL TROUBLESHOOTING CHART (Concluded).

TROUBLE	PROBABLE CAUSE	REMEDY
	c. Open condition in one or more of the column resistors.	c. The approximate resistance value of each column resistor is 400 megohms. Check each resistor for open conditions. Replace if necessary.
VACUUM SYSTEM Meter displays a fluctuating indication.	a. Accelerator tube "outgassing".	a. Condition the accelerator tube.
	b. Vacuum system leak.	b. Check the vacuum system for leaks.
	c. Insufficient system cooling.	c. Check the water cooling system for proper operation.
FOCUS Meter displays a zero indication.	a. Faulty circuit wiring.	a. Check all circuit wiring. Replace as necessary.
	b. Focus ring is faulty.	b. Replace focus ring if necessary.
	c. Faulty meter circuit components.	c. Check the meter circuit for proper operation. Replace components if necessary.

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## 2. CONTROL AND METERING SYSTEM

### a. Power Distribution Panel

This panel contains circuitry associated with the distribution and control of main power. It includes circuit breakers and line fuses for each major circuit. A schematic diagram is supplied with the accelerator, and should be consulted prior to troubleshooting this equipment.

- (1) Periodically check and clean. 120/208-volt, 50/60-cps, 3-phase, 4-wire, grounded-neutral main power must be available for the accelerator control circuits.

#### — WARNING —

ONLY QUALIFIED MAINTENANCE  
PERSONNEL SHOULD CLEAN IN-  
SIDE THE PANEL. BEWARE OF  
HIGH VOLTAGE.

### b. Operating Control Console

Operating control of the accelerator system is provided at a control console (see Figure 3, page 5). The function of all controls and indicators associated with the console is described in Section II, Operation.

- (1) Periodically check and clean the various chassis within the console.

NOTE: Watch for any obvious indication of trouble such as frayed or broken leads and broken or dented components.

- (2) All maintenance adjustments are described in the paragraph pertaining to the particular unit. For example, the generating voltmeter adjustments are found in the paragraph entitled GENERATING VOLTMETER, page 26.

### c. Selsyns and Control Rods

Two sets of selsyns are employed to remotely control the various terminal components. The master set is located at the control console. The slave set is located at the accelerator base (within the tank). The slave selsyns are coupled to the terminal controls by Lucite control rods.

- (1) Periodically check and clean the control rods.

---

— CAUTION —

DO NOT USE ACETONE TO CLEAN THE LUCITE CONTROL RODS. CRACKING OF THE RODS MAY OCCUR, WHICH WILL PROVIDE A HIGH RESISTANCE LEAKAGE PATH TO GROUND FOR THE TERMINAL VOLTAGE.

- (2) To remove a control rod without removing all the equipotential rings, remove or slide back a few of the top rings, de-couple the rod at both ends, bend it slightly to clear the terminal, and pull it through.
- (3) To check a selsyn: connect it to a master selsyn and check for brush contact and smooth operation, and proper tracking.

d. Generating Voltmeter

The generating voltmeter is used to measure the terminal potential and to provide a sensing signal for terminal voltage stabilization. (See References.)

- (1) Periodically check and clean it.
- (2) The accelerator VOLTAGE meter is calibrated by adjusting the resistive shunt (at the rear of the VOLTAGE meter) to the proton-lithium disintegration threshold of 1.88 MV. Use a lithium target and a neutron counter, establish the threshold, and adjust the shunt accordingly.

— CAUTION —

DO NOT EXCEED 2  $\mu$ A OF BEAM CURRENT. A HIGHER VALUE WILL DESTROY THE LITHIUM COATING ON THE TARGET.

- (3) To remove the generating voltmeter from the tank, the tank must be at atmospheric pressure.

e. Corona Stabilizing Tank Unit

The corona stabilizer assembly is used in conjunction with the stabilizing circuits to impose a controllable load on the terminal voltage. (See References.)

- (1) Periodically clean and check. Replace worn or damaged points.
- (2) For unanalyzed positive ion stabilization, (see References).
- (3) For analyzed positive ion stabilization, (see References).

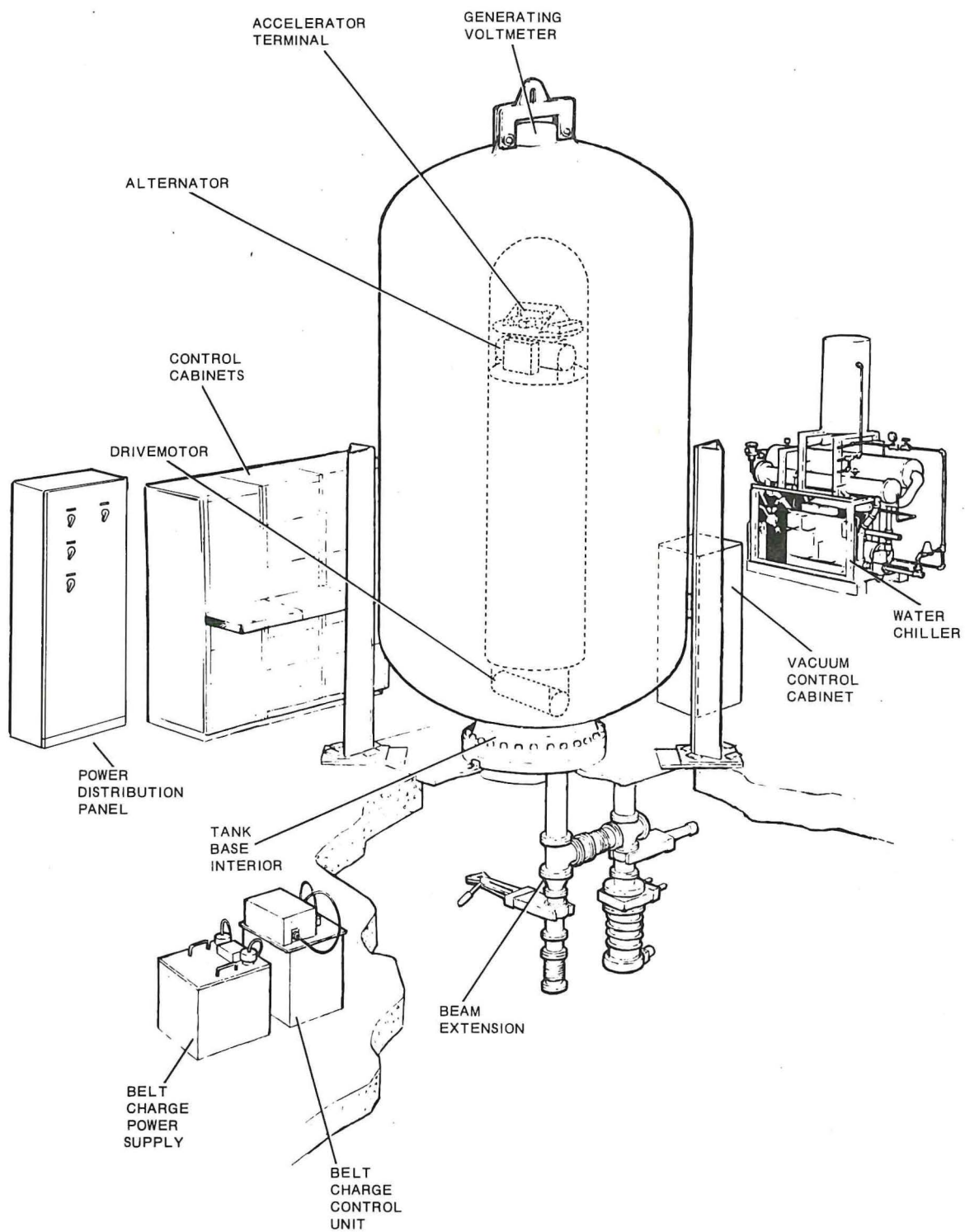


FIGURE 7. GENERAL ACCELERATOR TANK AND EQUIPMENT STATIONS

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### 3. TERMINAL VOLTAGE GENERATING SYSTEM

#### a. Pressurized Tank

The pressure within the tank should be maintained at the proper pressure. The pressurizing agent must be a combination of 20% carbon dioxide and 80% nitrogen (i.e., 55 psig CO<sub>2</sub> and 220 psig N<sub>2</sub>) or 65 psig for SF<sub>6</sub>.

#### — WARNING —

WHEN RELEASING THE GAS PRESSURE, EXERCISE CARE IN CONFINED ROOMS TO AVERT THE POSSIBILITY OF SUFFOCATION. ALWAYS USE A WALL EXHAUST OUTLET WHEN AVAILABLE.

- (1) Prior to removing the tank:
  - (a) Shut off the flow of cooling water
  - (b) Release the gas.
  - (c) Uncouple all connections.
  - (d) Remove the tank bolts.

#### — CAUTION —

WHEN REMOVING THE TANK, DO NOT ALLOW IT TO TOUCH THE COLUMN OR THE TERMINAL. REMOVE THE TANK VERY SLOWLY.

- (2) To remove the tank: position the hoist directly over the tank and lift the tank between the tank guides. Watch that the guides do not jam and that the tank does not interfere with the column. It is not advisable to leave the tank hanging over the work area.
- (3) Check and clean whenever the tank is removed.
  - (a) Examine the tank base gasket for possible damage and ascertain that it seats properly.
  - (b) Check the interior of the tank for spark tracks and particles which may indicate generator malfunction or damage:
    - i. Aluminum particles come from mechanical abrasion in the generator.
    - ii. Cotton particles come from the belt, either from frayed edges or sparking through the belt.
    - iii. Adhesive or glass particles come from the column or the tube.

- 
- iv. Clean the spark tracks on the inside of the tank and try to eliminate any rough or burred areas on the tank surfaces. Clean thoroughly; do not leave any residue.

CAUTIONS

- THE TANK BOLTS ARE SPECIFICALLY DESIGNED TO WITHSTAND THE TANK PRESSURE. DO NOT REPLACE THESE BOLTS WITH STANDARD COMMERCIAL BOLTS OF EQUIVALENT SIZE.
- THE PRESSURE TANK IS NOT TO BE EVACUATED UNTIL THE ACCELERATOR TUBE IS UNDER VACUUM. WITH THE ACCELERATOR TUBE AT ATMOSPHERIC PRESSURE AND THE PRESSURE TANK EVACUATED, THERE ARE REVERSE FORCES EXERTED ON THE TUBE WHICH TEND TO PLACE THE TUBE SEALS UNDER TENSION.
- DO NOT ATTEMPT TO PRESSURIZE THE TANK UNTIL ALL THE TANK BOLTS ARE PROPERLY SECURED.

- (4) Prior to pressurizing the tank, it must be roughed out.
- (5) Periodically check the dew point of the pressuring gas. (See HVI-1055, referenced in the Table of Contents.)

b. Belt-Charge Power Supply and Control Unit

These oil-insulated units control the charging current. The BELT-CHARGE ADJ. variac controls the operating range (0 - 50 kV) of the power supply. The CHARGING control establishes the output current through the control unit. The control unit provides a regulated output due to its constant current characteristics. (See HVI-486 and HVI-1093M1, referenced in the Table of Contents.)

NOTE: It is essential that the belt-charge power supply be conditioned as described in Instruction Bulletin HVI-486.

- (1) The coaxial cable, which connects the units to the charging screen, is a special single-strand conductor. The cable, if and when replaced, must be replaced by an identical cable. (HVE Part No. P-5956.)
- (2) A water flow interlock switch is located in the BELT-CHARGE input power circuit. This switch de-energizes the power supply when an insufficient cooling-water flow is being circulated through the target.
- (3) The output polarity of the belt-charge system may be reversed by interchanging the connections to J-8201 of the control unit and J-8102 of the power supply and by changing the setting of the plunger switch on the control unit.

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c. Terminal Spinning Assembly

The terminal spinning is the smooth, dome-shaped covering used to cover the terminal electronics. It is directly coupled to the high voltage terminal and maintained at the same potential. The spinning and the tank constitute the two plates of a capacitor with the insulating gas serving as the dielectric. The charge applied to the belt is stored by this capacitor. A portion of the charge bleeds off through the column resistors and establishes the voltage gradient between the terminal and ground. To avoid corona type discharges (arcing) between the spinning and the tank, the spinning must be maintained as smooth and clean as possible.

— WARNINGS —

- DO NOT PERFORM MAINTENANCE ON AN OPENED ACCELERATOR UNTIL THE HIGH VOLTAGE TERMINAL PLATE HAS BEEN GROUNDED TO THE ACCELERATOR BASE PLATE.
- SERVICE OF THE ACCELERATOR MUST BE PERFORMED BY TEAMS OF TWO OR MORE MEN AT ALL TIMES.

- (1) Check the terminal spinning whenever the tank is removed. There should be no scratches, gouges, sharp edges, or dents on any part of the spinning. To remove such flaws, use only fine emery paper that has been loaded with grit-free hand soap. Follow this with buffing, if possible, or clean and polish with a dry cloth.
- (2) The terminal spinning is held in position (approximately 1/2-inch above, and concentric with, the top column ring) by four clamps. Each clamp has a setscrew and two hold-down cap screws. To remove the spinning:

NOTE: It will be necessary to remove a few of the top column rings to create enough work space.

- (a) Loosen the setscrews and hold-down screws of the clamps.
- (b) Support the terminal spinning and push back the clamps and finger-tighten the hold-down screw.
- (c) Lift straight off.

— CAUTION —

AVOID GOUGING THE INSIDE AND/OR THE OUTSIDE OF THE TERMINAL SPINNING.

- (3) Prior to re-installing the terminal spinning, clean the inside of it with a solvent. Do not leave residue. To re-install, reverse the preceding steps.

---

#### d. Charging and Collector Screens

Both screens are made of stainless steel and are trimmed to present a series of sharp corona points to the belt. The charging screen is mounted on, but insulated from, the tank base and maintained at up to plus 50 kV by the BELT-CHARGE units. This positive potential at the screen wipes off electrons from the up-run side of the charging belt, thereby leaving the belt positively charged. The belt travels towards the terminal. At the terminal, the collector screen, which is mounted mechanically and electrically to the terminal plate, faces the up-running side of the belt. Electrons are attracted to the positively charged belt through the collector screen. These electrons are electrostatically held by the belt and transported to ground through the charging screen. This constant removal of electrons from the high-voltage terminal establishes a positive potential at the terminal with respect to ground.

- (1) Whenever the tank is removed from the accelerator, check both screens.

#### — WARNING —

ALWAYS DE-ENERGIZE THE BELT-CHARGE SYSTEM PRIOR TO WORKING ON THE CHARGING SCREEN.
---

- (a) Examine the working edge of the screens.
  - (b) If the exposed screen is less than 1/2-inch long, replace it. Remove two cross wires on all new screens.
  - (c) If the points are too short (less than the width of one mesh), remove one or two cross wires from the edge so as to lengthen the points to approximately the width of two meshes.
  - (d) If the alignment of the points is irregular, trim them to a straight line and remove one cross wire.
  - (e) Carefully bend the CHARGING screen to a 15-degree angle and the COLLECTOR screen to a 30-degree angle, in the direction of belt travel. Exercise care not to bend, pull out of alignment, or in any way injure the corona points of the screens.
  - (f) Carefully adjust the screens to insure a uniform, moderate pressure contact along the belt surface.
- (2) Always replace both screens whenever a new belt is installed.
  - (3) Whenever the CHARGING screen is removed, check the resistance of the series resistors. Each resistor should be approximately 20 megohms. Also check the conditions of the insulator bar. Replace the bar if any cracks or burned spots are evident.
  - (4) Whenever the COLLECTOR screen is re-installed, check the "Mykroy" belt guide. The clearance between the belt guide and the stationary belt should be set to approximately 1/16 of an inch.

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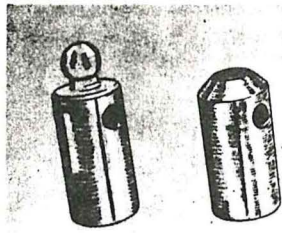
e. Charging Belt

The charging belt is specially designed and fabricated to carry both the electrostatic and the mechanical loads imposed upon it. It is driven by an inverted motor which is contained within the drive pulley at the base of the accelerator. The belt is supported at the upper terminal by the terminal pulley. The terminal pulley rests on pillow blocks which are adjusted to provide a static belt tension of approximately 900 lbs. per side.

- (1) Periodically check the charging belt for frayed sides, burns, or deterioration. If replacement becomes necessary, refer to the belt removal and the installation instructions contained within this
- (2) Adjusting the Belt Tension -- The psi reading stamped on the pump ram has been calibrated for the hydraulic unit and is to be used to attain the 900-lb. tension. To adjust the belt tension refer to Figure 9, page 34.
  - (a) Loosen the locking nut at each end of the terminal pulley under the pillow blocks.
  - (b) Loosen the setscrews that fasten each pillow block to its guide rods. There is a total of four setscrews.

NOTE: Do not loosen the setscrews that fasten the guide rods to the channel.

- (c) Insert the jaws of the tension meter (HVE Part No. C-K-TO-10) between one of the pillow blocks and the channel below the block.
  - (d) Pump the handle of the tool to spread the jaws until the tension meter indicates the number stamped on the pump ram.
  - (e) Turn the pillow-block adjusting screw until it seats against the pillow block, as indicated by the point at which the tension meter indication decreases. Remove the tension meter.
  - (f) Repeat steps (c) and (e) on the other pillow block.
  - (g) Adjust for belt tracking.
- (3) Adjusting the Belt Tracking -- Adjustment for belt tracking should always be performed after belt tensioning. The charging belt must track over the center of both the upper and lower pulleys. To adjust for belt tracking:
    - (a) Ground the terminal.



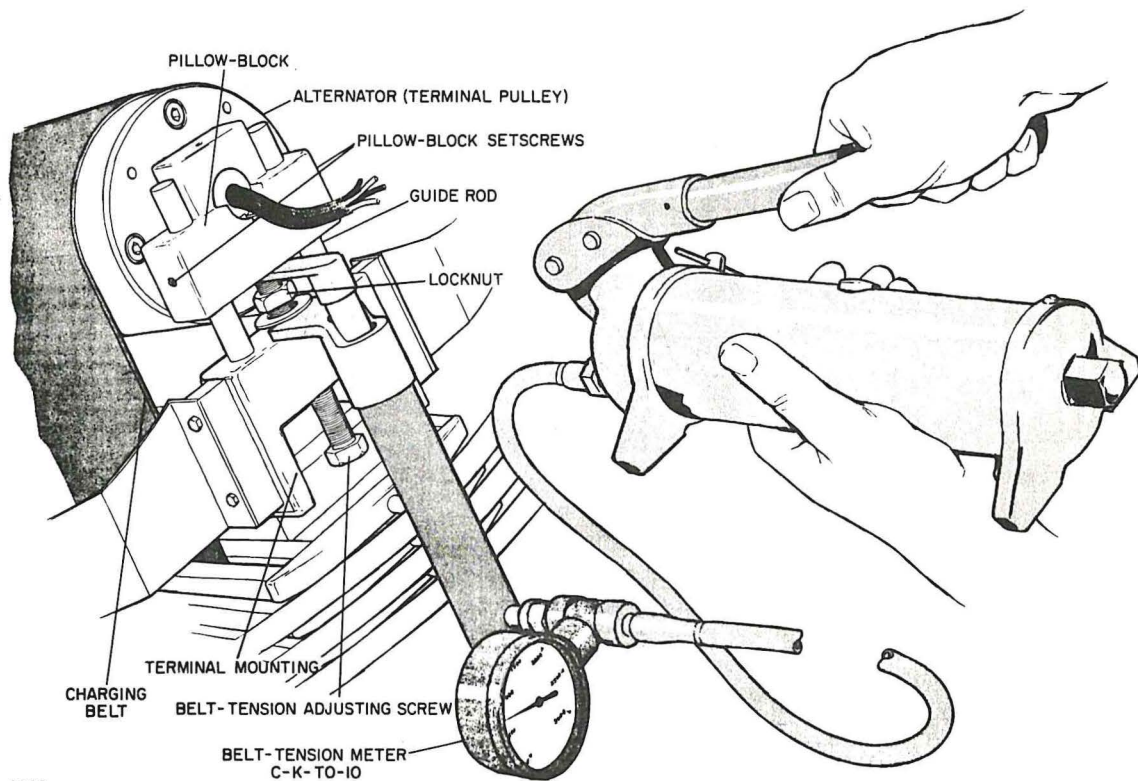
TOP  
EXTENSION

BOTTOM  
EXTENSION

**BELT-TENSION  
ROD EXTENSIONS**

**NOTE**

THE BELT-TENSION ROD EXTENSIONS ARE USED TO PROVIDE AN ADDITIONAL INCH OF ADJUSTMENT LENGTH TO THE BELT-TENSION ADJUSTMENT SCREW. TO INSTALL: LOOSEN THE PILLOW-BLOCK SETSCREWS, COMPLETELY BACK-OFF THE BELT-TENSION ADJUSTMENT SCREW, RAISE THE PILLOW-BLOCK TO CLEAR THE SCREW AND INSTALL THE EXTENSIONS (see adjacent illustration)



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**FIGURE 8. BELT TENSION ADJUSTMENT**

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— WARNING —

DO NOT OPERATE THE CHARGING BELT UNLESS THE TERMINAL PLATE IS GROUNDED TO THE GENERATOR BASE. CAUTION SHOULD BE EXERCISED IN THE PRESENCE OF RUNNING BELTS, ESPECIALLY NEW ONES. UNLESS THE TERMINAL IS GROUNDED, THE BELT CAN BUILD UP ENOUGH SELF-CHARGE AND TERMINAL VOLTAGE TO CAUSE RADIATION.

- (b) Jog the drivemotor with the local drivemotor switch to determine if the belt will track.
- (c) If the belt slides to either side, raise the pillow block on that side.
- (d) Recheck the belt tension. If further adjustment is necessary, repeat the belt tracking procedure.
- (e) After adjusting the belt tension and tracking, tighten all locknuts and setscrews.
- (f) Operate the drivemotor in air, BUT NOT OVER 20 MINUTES AT A TIME. The drivemotor heats up if not operated under the high pressure for which it is designed. Overheating will damage the bearings and burn out the motor.

NOTE: Two thermistors (one per side) are inserted into the drive pulleys to monitor the pulley heat. When the temperature rises above a safe level, the signal from the thermistors will actuate a protective circuit to de-energize the drivemotor. (Reference HVI-1084M1 in the Table of Contents.)

- (g) Run the belt and observe its action at the terminal pulley. If the belt slides toward either side of the terminal pulley, repeat the preceding steps.
- (4) Removing the Charging Belt -- The charging belt is removed by simultaneously sliding the belt from the upper and lower pulley. To remove the belt:
- (a) Remove all the column rings, outer belt spacers, and gradient bars.
  - (b) Remove a minimum of six end bars at each end from the side of the column over which the belt will be removed. (Refer to Figure 9, page 36.)
  - (c) Remove the charging and collector screens.
  - (d) Remove the belt shield located at the bottom of the column.
  - (e) Loosen the locknuts and setscrews on the alternator pillow blocks. Loosen the adjusting screws. This relieves the tension on the belt.

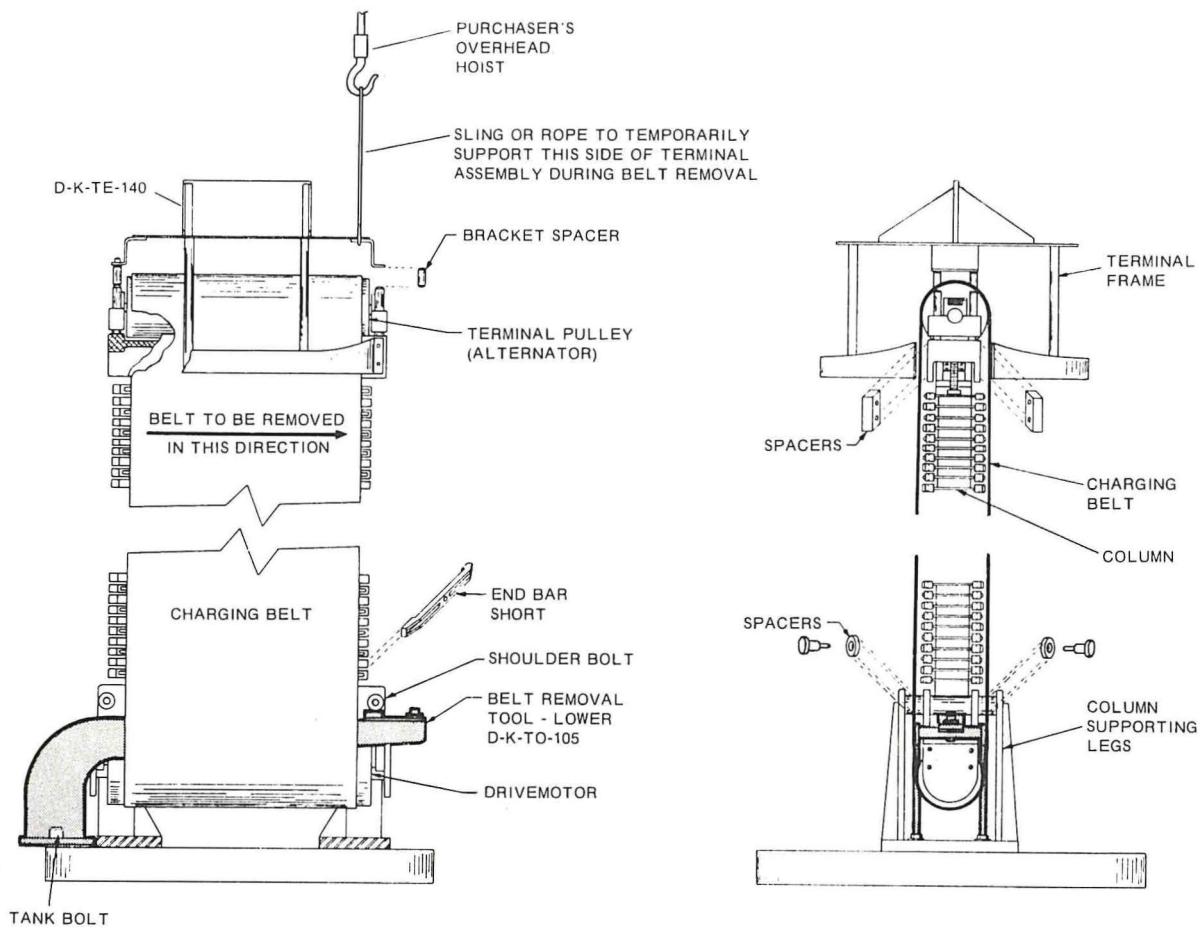


FIGURE 9. CHARGING BELT REMOVAL

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- (f) Insert the Lower End Belt Removal Tool, Part No. D-K-TO-105. This tool holds the column up with one side open so that the belt can be removed. (See Figure 9.)
- i. Remove the block from the ends of the support bracket fork of the belt removal tool.
  - ii. Insert the belt removal tool into the column. The point of entry for the tool is about five inches above the end of the drive pulley with the three power leads. The tines of the fork are parallel to the axis of the pulley and inside the legs of the bracket that supports the mounting channel. The tines are outside of the mounting channel and inside the belt.
  - iii. Bolt the base of the tool to the accelerator base, using the two tank bolt holes which coincide with those of the tool. The foot pads on the tool base will keep the "O" ring from being crushed.
  - iv. Bolt the fulcrum block between the tips of the fork so that the lever plate extends back under the bolts of the support channel.
  - v. Turn the jacking screw until the lever plate supports the column. The belt removal tool will now support one side of the column and permit removal of the belt when the bolts are withdrawn from the support channel. To determine when the jacking screw has been turned far enough, place an Allen wrench in both the shoulder bolts on the side from which the belt will be removed. Turn the jacking screw, and try to turn the Allen wrenches back and forth. When both Allen wrenches can be turned, stop turning the jacking screw on the tool.
- (g) Insert the Upper End Belt Removal Tool, D-K-TO-31. This tool hooks onto one end of the channel that carries the terminal and swings up and over the terminal. It is fastened to the top of the terminal frame assembly to carry the weight of that unit while the belt is removed.
- i. With the hand knob, remove the two bolts from the block on the tool end.
  - ii. Remove the terminal spinning support block from the upright plate in the center of the terminal assembly.
  - iii. Fit the hooks of the tool over the heads of the two outermost screws inside either end of the channel.
  - iv. Swing the tool upright until the slot of the block on the tool fits over the upright plate on the terminal.
  - v. Replace the two bolts, removed in step "i", to fasten the tool to the plate.
  - vi. Tighten the hand knob until the tool bears the weight of the terminal.
-

- 
- vii. Remove the two bracket spacers and the two post studs and disconnect the wiring where necessary on the side where the belt is to be removed.
  - (h) Carefully slide the belt off both the upper and lower pulleys.
  - (i) Proper initial conditioning of a new belt will increase its life. A gradual wearing-in of new screens contributes to voltage stability. Slow application of generator voltage and charging current helps to burn off residual lint and dust and conditions the belt surface as the belt surface temperature rises. Such a process is coincident with terminal and tube conditioning after installation and is, therefore, essential.
- (5) Prior to Installing a belt:
- (a) Check the column alignment and clean the upper and lower pulleys. Abrade the pulleys with a fine sandpaper, wash them with white gasoline (non-lead petrol from petroleum sources--not coal sources) or pure heptane, and wipe clean to remove all residue.
  - (b) Clean the column resistors, gradient rods and charging assembly with a dry cloth. Clean and blow out the column and pressure tank thoroughly. Inspect the column for loose spark gaps, loose tube connectors or damaged column insulators.
  - (c) Clean the belt spacers by wiping them with a dry cloth, then with a cloth impregnated with white gasoline. All belt spacers in the column should be cleaned in this manner. Use the solvent liberally. Carefully inspect each belt spacer for cracked or broken porcelain. Replace any which show even the most minute sign of damage.
- (6) Installing the Charging Belt -- Successful operation and long charging belt life are strongly dependent upon proper installation and conditioning of the belt. Contamination of the belt surfaces with any foreign materials such as grease, dirt or solvents can seriously impair accelerator operation, and can result in uncontrollable self-charging of the generator. The belt, as furnished, is clean. It should be handled with white cotton gloves and installed with as little scuffing or scraping as possible.

— WARNING —

EXERCISE PROPER FIRE PRECAUTIONS  
WHEN USING SOLVENTS.

- (a) Slide the belt over the upper and lower pulleys.
- (b) At the upper pulley end:
  - i. Replace the two bracket spacers and the two post studs.
  - ii. Loosen the hand knob of the belt removal tool.
  - iii. Remove the tool.

- 
- iv. Replace the terminal spinning support block.
  - v. Replace the two bolts in the support block of the belt removal tool.
  - (c) At the lower pulley end:
    - i. Replace the two spacers and the two bolts that fasten the support channel.
    - ii. Loosen the packing screw of the belt removal tool.
    - iii. Remove the fulcrum block.
    - iv. Remove the tool.
  - (d) Replace the end bars, belt shield, etc. Do not excessively tighten the screws on the end bars.
  - (e) Re-adjust the top and bottom six end bars.
  - (f) Install new charging and collector screens each time the belt is replaced.
  - (g) Adjust the belt tension and belt tracking.

NOTE: The belt may stretch when first put into service. Readjust belt tension and belt tracking when necessary.

- (h) Ground the high voltage terminal if not done. "Jog" the belt and adjust for proper tracking on both pulleys. Operate the belt for 10 minutes in air, then reset the belt tension to compensate for initial stretching. Repeat this procedure twice. Check the belt tracking. Tighten the locking screws in the pillow blocks.

— CAUTION —

TO AVOID OVERHEATING THE BEARINGS, DO  
NOT RUN THE DRIVEMOTOR MORE THAN  
TWENTY MINUTES IN AIR AT ANY ONE TIME.

f. Drive and Terminal Pulleys

These units provide the drive and the support for the charging belt. The drive pulley is mounted at the base and contains a 20 hp, 3-phase, 50/60 cps motor. The terminal pulley is mounted on adjustable pillow blocks and contains a 125-volt, 400 cps, 1500 watt alternator. (See HVI-1031M3 and HVI-1087, referenced in the Table of Contents.)

- (1) Removing the Terminal Pulley -- (Refer to Figure 9).
  - (a) Remove the electrical connections from the alternator to the terminal.
  - (b) Remove the collector screen.

- 
- (c) Fit blocks between the bottom of the alternator and the channel at the top of the column.
  - (d) Loosen the tension-screw locknuts.
  - (e) Remove the top end bar from the side through which the alternator will be removed.
  - (f) Loosen the pillow-block setscrews.
  - (g) Loosen the tension screws and remove the extension guide rods (if used) between the tension screws and the pillow blocks.
  - (h) Fit thinner blocks between the alternator and the channel that are approximately level with the top of the casting holding the guide rods.
  - (i) Loosen the tension screws until they are below the casting.
  - (j) Remove the guide rod extensions from the side through which the alternator will be removed.
  - (k) Loosen the setscrews on the top-side guide rods and remove the guide rods.
  - (l) Remove the pillow block from the side through which the alternator will be removed.
  - (m) Slide the alternator out through the opening made by the preceding steps. This must be done by two men using a hoist.

— CAUTION —

DO NOT ALLOW THE SURFACE OF THE PULLEY TO BECOME DENTED.
---

- (n) If it becomes necessary to remove the pillow-block castings from each end of the alternator shaft:
    - i. Remove the setscrew securing the carbon brush to each end of the alternator.
    - ii. Remove the brushes.
    - iii. Remove the castings.
  - (o) For maintenance information, see References.
- (2) Removing the drive pulley:
- (a) Release the belt tension and remove the terminal pulley.
  - (b) Disconnect the drivemotor wiring from the thyrite protectors at the generator base.
  - (c) Remove the thermistors from both ends of the drive pulley.
  - (d) Remove the charging screen.
  - (e) Remove the ground shield.
-

- 
- (f) Remove the setscrew securing the drivemotor shaft to the pulley flanges.
  - (g) Remove the carbon brush from each pulley flange by removing the setscrew securing each brush to the flange.
  - (h) Remove the four Allen screws from the plate of the pulley flanges.
  - (i) Pull one pulley-flange straight out until it is free of the pulley shaft.
  - (j) Remove the pulley. Be careful not to scratch the surface of the drive pulley during this operation.
  - (k) For maintenance information, refer to Reference No. 7.

g. Equipotential Planes

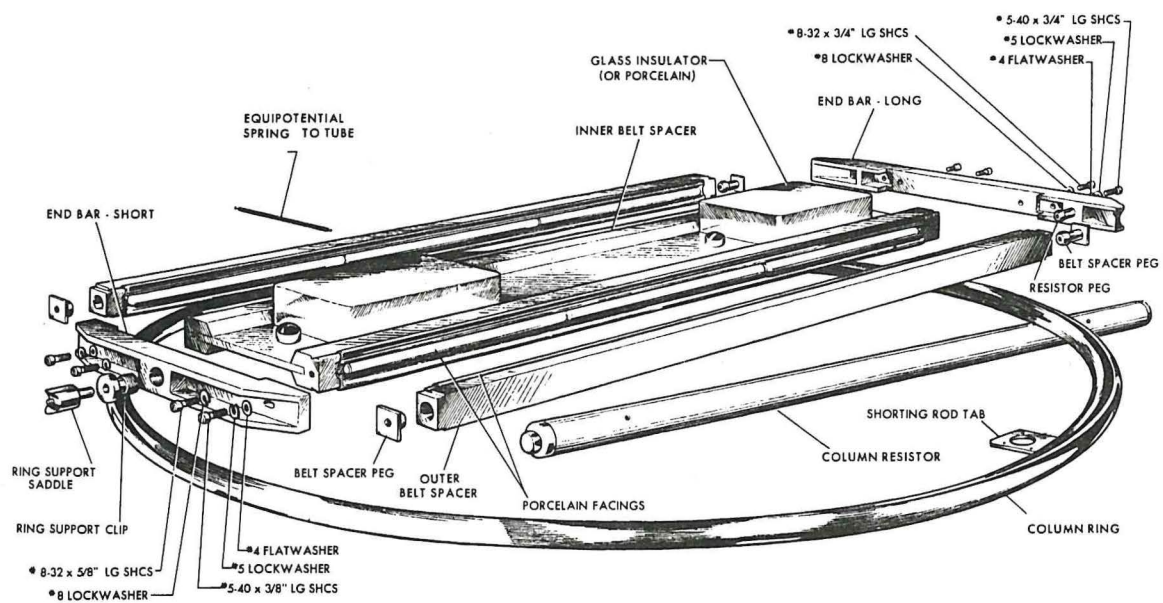
The voltage gradient which accelerates the positive ions is developed through a series string of resistors. Each resistor interconnects adjacent planes down the length of the column. An equipotential plane is comprised of: belt spacers (or gradient bars), end bars, and column rings, all of which are mounted on an equipotential section of the column. (Refer to Figure 10.)

- (1) The Column Ring -- The ring is held on one side by the saddle-shaped (long) end bar and on the other side by an adjustable stud in the center of the short end-bar. The stud may be screwed in or out to adjust the tension of the ring. The ring is firmly held by a locking pin in the stud which engages a hole in the inner surface of the ring. The locking pin device is used to ensure proper alignment of the shorting rod tabs.  
To remove:
  - (a) Spring them by squeezing slightly, remove them from the stud and the lower end-bar, and slide them over the terminal.
  - (b) Store the removed rings in the storage rack provided for this purpose.

— CAUTION —

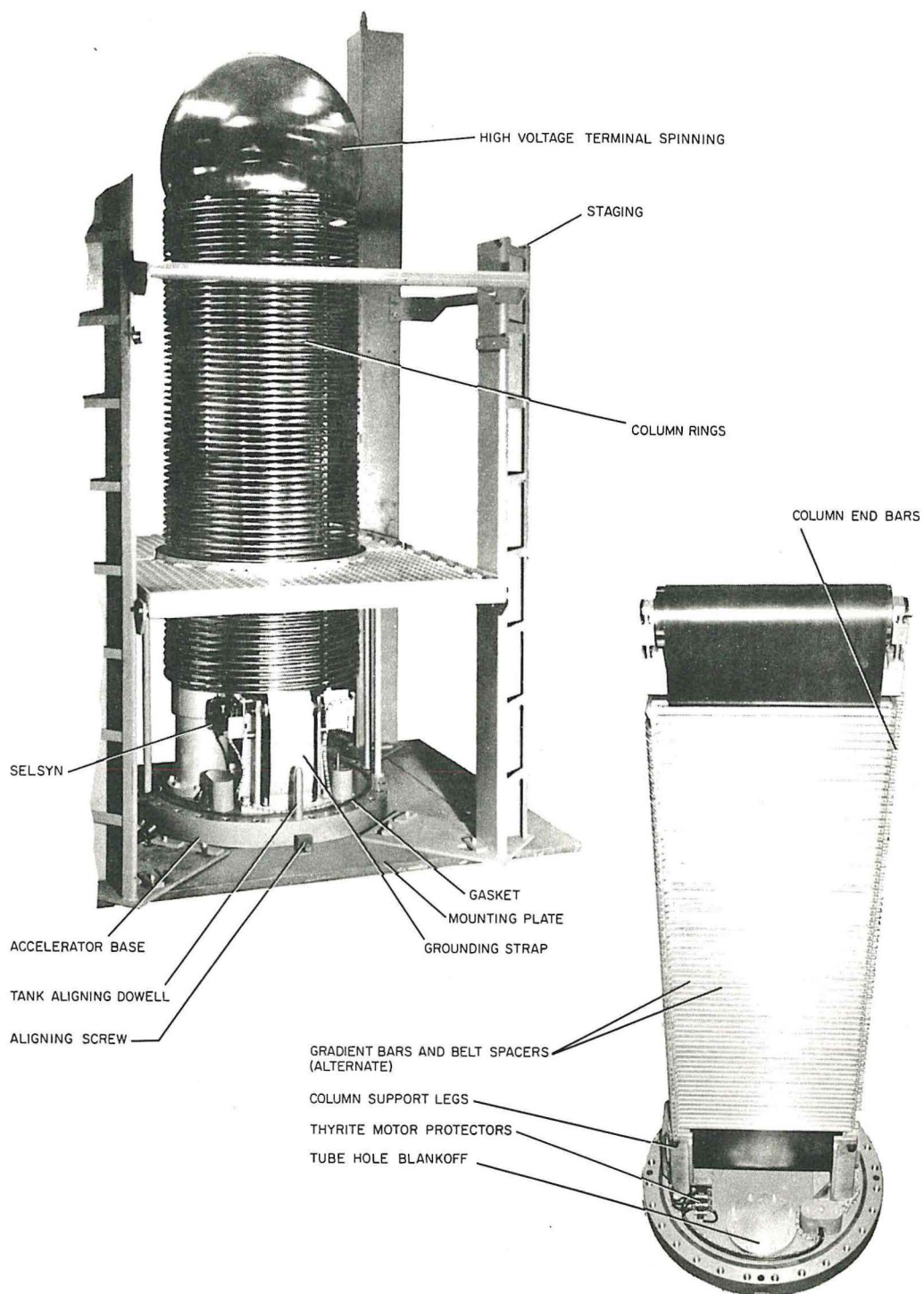
DO NOT ALLOW THE RINGS TO BE  
DENTED OR BENT.

- (c) Before re-installing the rings on the column, wipe the rings with a clean cloth moistened with a solvent.
- (2) The Column Resistors -- The resistors are installed on the opposite side of the column away from the tube, outside of the outer spacers and gradient bars. One end of each resistor is spring-loaded and fits over a stud on an end bar. The other end has a stud which fits into a hole on the other end bar. The resistor between the bottom equipotential plane and the ground plate is insulated from the ground plate and is connected to ground through the current metering circuit on the control cabinet. The current through the voltage divider is the column current. This current depends upon the terminal voltage and the values of the column



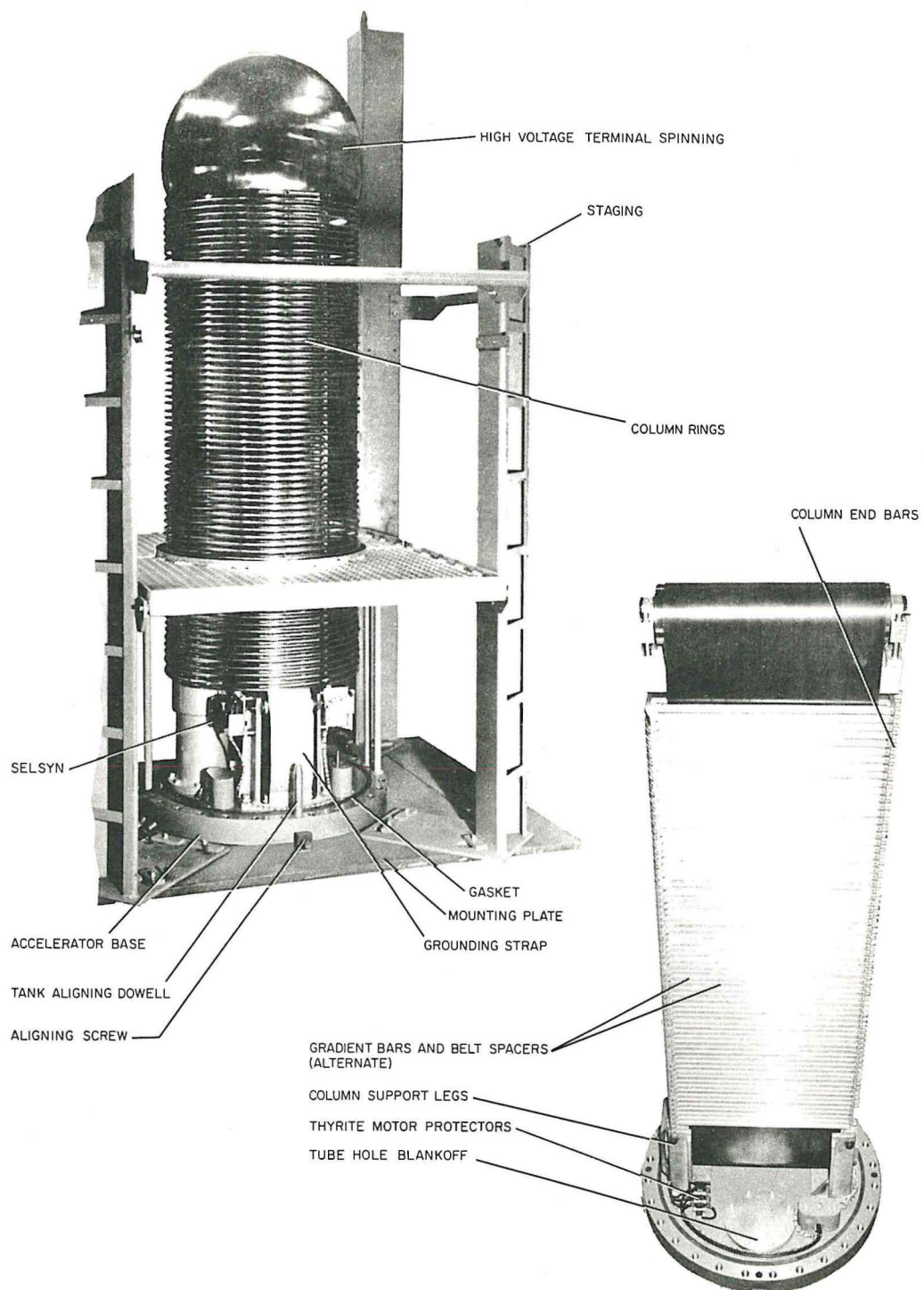
1177

FIGURE 10. EQUIPOTENTIAL PLANE



1744

FIGURE 11. GENERATOR BASE COLUMN STRUCTURE AND STAGING



1744

FIGURE 11. GENERATOR BASE COLUMN STRUCTURE AND STAGING

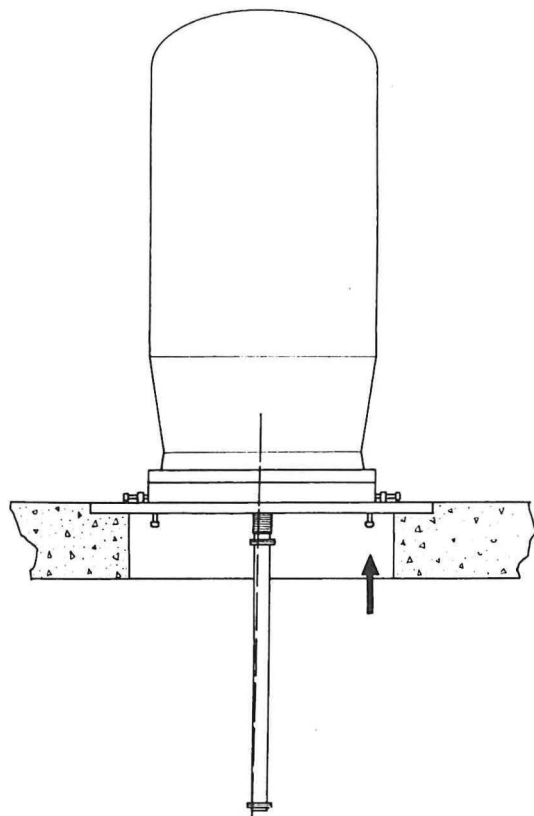
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resistors. Any significant variation from normal is an indication of abnormal operation.

- (a) The resistors mount diagonally to interconnect adjacent planes. To remove a column resistor, move it lengthwise to compress the spring, and swing the stud end of the resistor in or out, as required.
- (b) Inspect the resistor for signs of electrical breakdown. Carbonized matter resulting from voltage breakdown can cause irregular operation.
- (c) Calculate the value of each resistor by applying a high voltage (30 - 40 kV) across the resistor and measuring the current through it. Each resistor should be within 10% of the mean value of all the column resistors. Note that the high voltage power supply is recommended to simulate actual operating parameters.
- (d) Due to high voltage arc-over, it is conceivable that the preceding step will not detect an open resistor. To ensure against a resistor being open, measure the resistance with a 500 - 1000 V megohmmeter.

NOTE: The resistors must make firm contact at both ends to avoid arcing which, in turn, can affect the stability of operation.

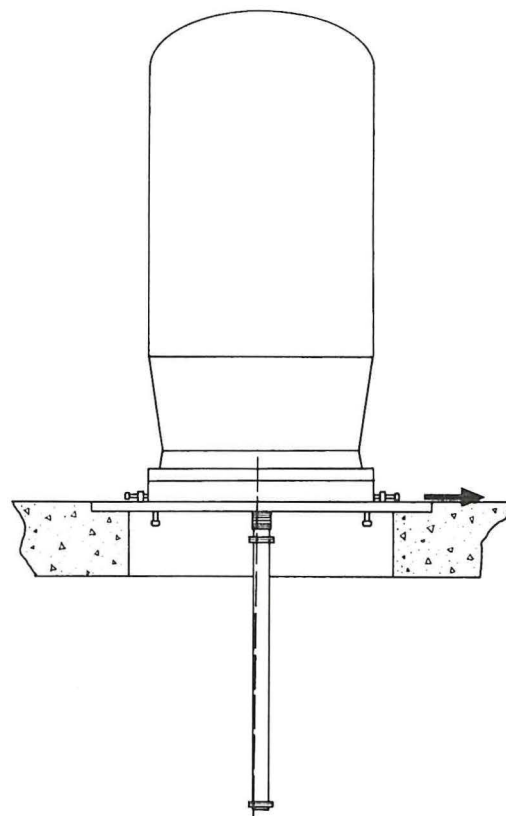
- (3) Gradient Bars and Belt Spacers -- Two sets of these units are installed in the column (inner and outer sets). They form a channel for the belt to travel through. The aluminum gradient bars are installed to reduce the electrical stresses between the charged belt and the column. The porcelain belt spacers are installed to prevent belt slap.
  - (a) The outer set is suspended between the two end-bars of their respective planes. Each of the end bars on both sides of the column contains a stud mounted in an elongated hole; one end of each gradient bar and belt spacer contains a hole that engages the stud. A hole in each of the end bars on the other side of the column contains a spring. This spring is compressed by the stud and serves to lock the gradient bars or belt spacers in place. Each stud is locked rigidly to the end bar with a screw that passes through the end bar.
  - (b) Removing the outer set requires the removal of the column rings, the tube-connecting springs, and the column resistors. Note that adjacent planes have either a gradient bar or a belt spacer. When re-installing, exercise care to alternate one from the other for each adjacent plane. Belt spacers are mounted first and last. To remove:
    - i. Apply axial pressure to the gradient bar or belt spacer to compress the spring and swing the stud end away from the column.
    - ii. Disengage the other end and withdraw the unit from the plane.



IF THE BEAM SPOT IS OFF CENTER TO THE LEFT

LIFT THE RIGHT SIDE OF THE GENERATOR

OR



SHIFT THE WHOLE GENERATOR TO THE RIGHT

1743

FIGURE 12. BEAM CENTERING ALIGNMENT

- 
- (c) The inner set is fastened to the column plane by dovetail joints.
  - (d) Removing the inner set requires removing the top end-bar and sliding the unit up off the dovetail joint. Again note that adjacent planes have either a gradient bar or a belt spacer.

— CAUTIONS —

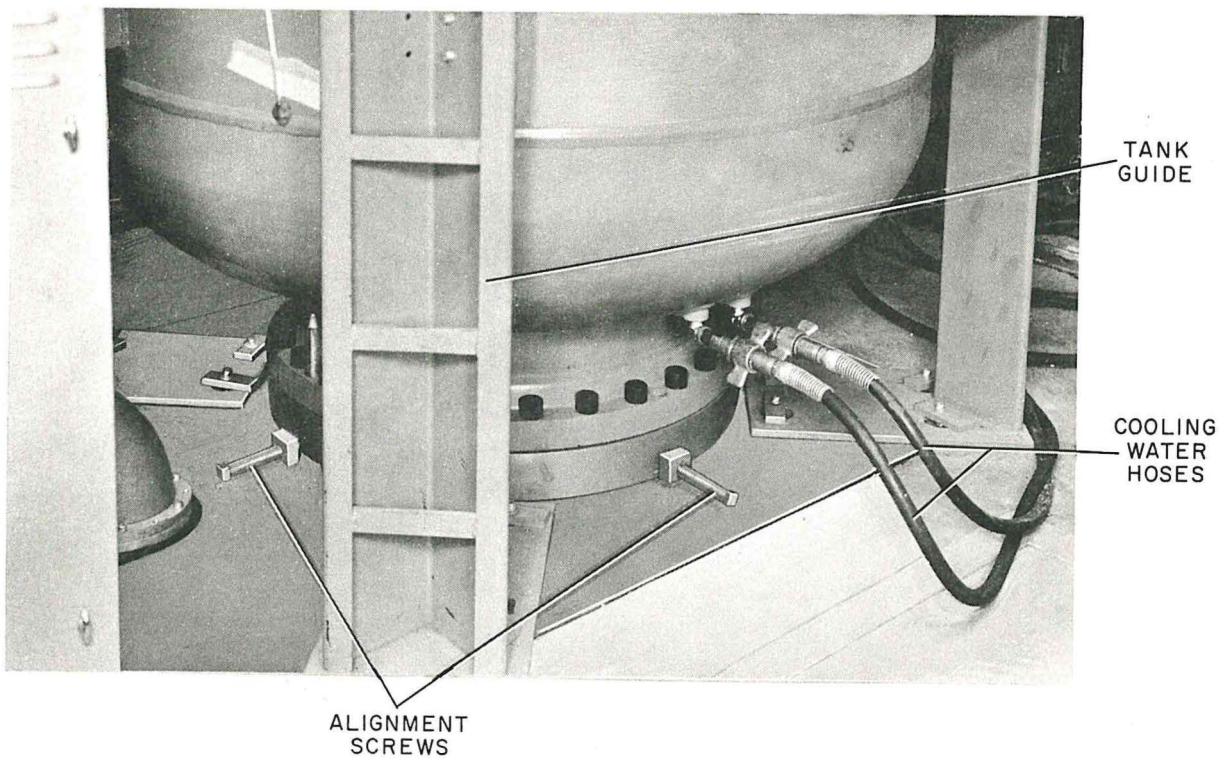
- WHEN RE-INSTALLING OUTER AND INNER GRADIENT BARS OR BELT SPACERS, ALWAYS MATCH THE OUTER SET TO THE INNER SET. AN INNER GRADIENT BAR MUST NOT FACE AN OUTER BELT SPACER, AND VICE VERSA.
- WHEN HANDLING BELT SPACERS, DO NOT PERMIT THE PORCELAIN TO RUN AGAINST THE ALUMINUM BAR; THIS MAY CREATE ELECTRICALLY CONDUCTIVE MARKS.
- DO NOT ALLOW CONTAMINANTS TO SETTLE ON THE PORCELAIN INSULATORS.
- DO NOT USE SOLVENTS TO CLEAN BELT SPACERS.

- (e) The porcelain insulators of the belt spacers should be checked for mechanical or electrical failure. An ordinary ink eraser should be used to clean the insulator, and fine sandpaper can be used on any patches which may persist.

#### h. Column Structure

This unit mounts and supports the major portion of the accelerator assemblies. Structurally, the column consists of a number of stainless steel planes arranged in a column and separated from each other by glass or porcelain insulators of uniform thickness. Hemispheres are mounted on each side of each equipotential plane and are so located that they form a series of spark gaps down the column. These spark gaps protect the column insulators against voltage surges. The bottom plane is attached to the column support member. The top of the column structure supports the terminal pulley and terminal assembly. The column structure, once installed, becomes a fixed part of the accelerator and is not prone to wear or damage.

- (1) Removal of the column is rarely necessary. If removal of the column is required, use the following procedure:
  - (a) Strip the column of all components (rings, gradient bars, etc.).
  - (b) Remove the selsyn mounting plates on the base. This permits access to the lower drive pins.
  - (c) Loosen the two setscrews on each of the terminal drive pins that hold the upper support channel and the top of the terminal together. Drive the pins out with a soft driftpin. This frees the channel and the alternator mount for removal.



**FIGURE 13. ALIGNING THE ACCELERATOR**

- 
- (d) Install the column lifting jig (C-K-TO-7). The pins of the two shackles fit into the drive pin holes located in the preceding step. Hook a hoist to the jig and take up the slack.

— CAUTIONS —

- UNDUE STRAIN MAY DAMAGE THE COLUMN.
- THE COLUMN MUST BE PLACED ON ITS NARROW SIDE TO AVOID DAMAGE.
- THE COLUMN IS SENSITIVE TO THERMAL SHOCK AND SUDDEN TEMPERATURE CHANGES.
- SHIP THE COLUMN VIA TEMPERATURE-CONTROLLED TRANSPORTATION (40 °F MINIMUM AND 150 °F MAXIMUM).

- (e) Loosen the setscrews on the lower drive pins and drive out the pins with a soft driftpin. The column is now free.
- (f) Fit the column tipping jig around the column. Tighten the pieces firmly. Hook the sling to the two eye bolts. Lay the column on the floor on the narrow side.
- (g) To ship, use the shipping crate in which the new column was shipped. The column must be shipped in the tipping jig.
- (2) Adjusting the column for belt clearance is performed prior to installing the belt. The two inside rows of the belt spacers are all positioned simultaneously by shifting the column with respect to the generator base and/or by shifting the terminal pulley with respect to the column.

— CAUTION —

WHEN INSTALLING OR ADJUSTING THE COLUMN,  
USE THE COLUMN-LIFTING JIG TO HOLD THE  
COLUMN IN PLACE.

- (a) Loosen the 1/4-inch Allen cap screws that clamp the split blocks at the base of the column to the base pins.
- (b) Loosen the 1/4-inch setscrews that clamp the column on the terminal pins.
- (c) Stretch a loop of string or wire around both pulleys, 5 inches in from the ends (to simulate the belt).

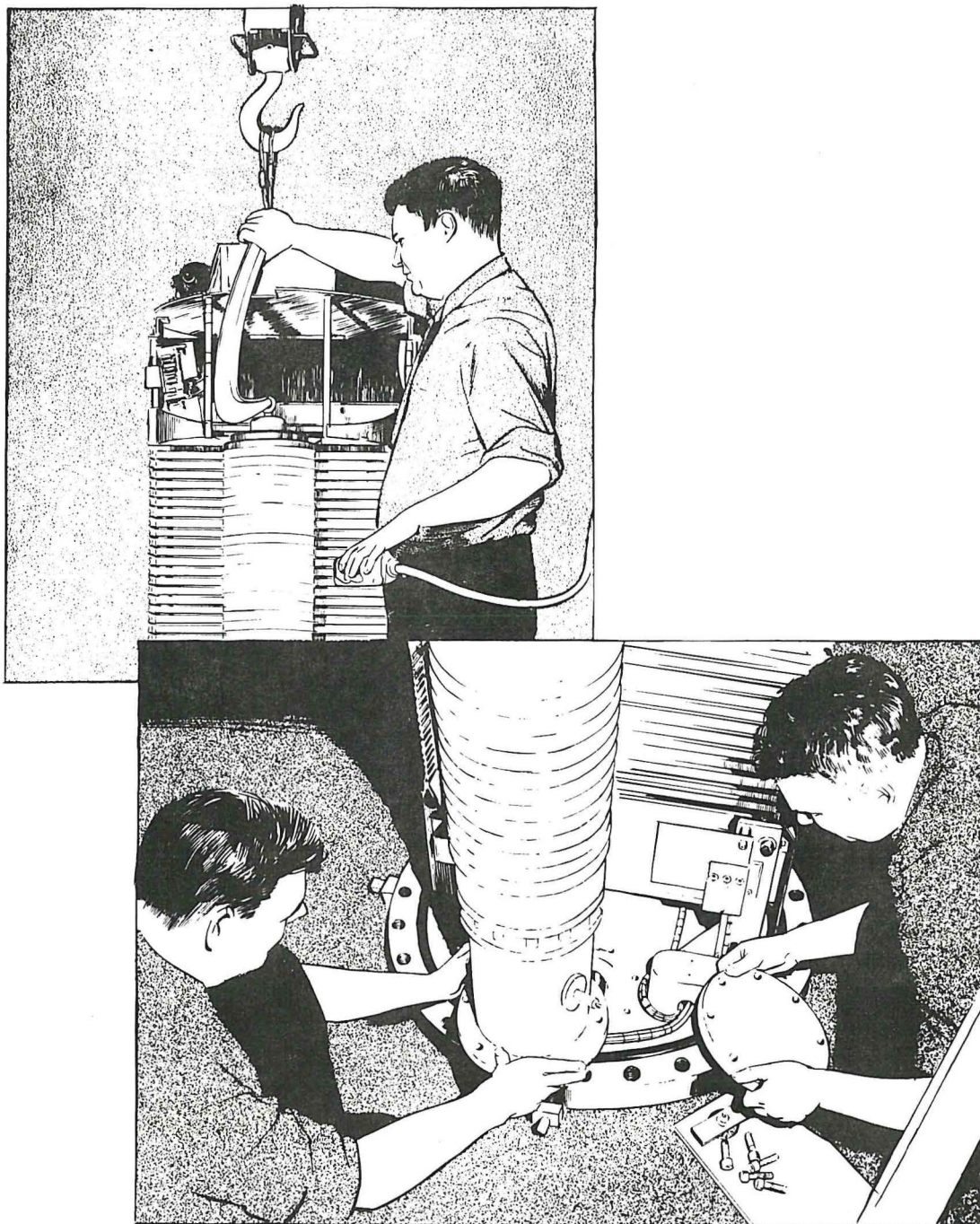


FIGURE 14. REMOVING THE ACCELERATOR TUBE

- 
- (d) An Allen setscrew is located in the outside end of each flange of each channel (3/8-inch screws are used at the base, and 5/16-inch screws at the terminal; there is a total of eight setscrews). Turn these screws in order to move the column along the pins until the space between the inner spacers and the string or wire (used to simulate the belt) is equal on each side at both ends.
  - (e) Tighten the setscrews when the clearance on each side of the column is equal.
  - (f) Install the charging belt and install the outer set of gradient bars and belt spacers.

i. Generator Base Mount and Alignment

This unit is the support structure for the accelerator components. Adjustment screws, at its base, allow the entire accelerator to be tilted and/or shifted. These screws are used to center the beam on the target. When the accelerator tube has been aligned, the beam will enter the accelerator tube extension at approximately the center of the bellows. If the beam does not strike the center of the target, it is necessary to adjust the alignment between the accelerator tube, tube extension, and the generator. The tube extension is fixed in position by hanging rods which support it; it has been levelled at installation.

- (1) Prepare the accelerator for operation with a viewer target cartridge.

— WARNING —

OBSERVE ALL PRECAUTIONS AGAINST HIGH VOLTAGE AND RADIATION. THIS PROCEDURE ONLY APPLIES TO POSITIVE ION ACCELERATORS.

- (2) Start the accelerator and increase the beam current to approximately 3  $\mu$ A maximum at operating voltage.
- (3) Insert the unanalyzed beam viewer target cartridge, and twist it 1/2-turn to the right to present the Vycor surface to the beam. (Vycor is a manufactured crystalline silica formation used in place of a natural quartz.)

— CAUTION —

DO NOT EXCEED 5  $\mu$ A BEAM CURRENT ON THE VYCOR SURFACE OF THE VIEWER-TARGET CARTRIDGE.

- 
- (4) Observe the beam spot on the Vycor surface of the viewer cartridge through the observation portal opposite the viewer.
  - (5) If the beam spot is off center, tilt or shift the entire accelerator in the appropriate direction to center the beam spot on the viewer.

#### 4. ACCELERATING SYSTEM

##### a. Accelerator Tube

The accelerator tube is provided to enable the voltage developed by the generator to be used to accelerate positive particles. The tube is a highly evacuated, tubular unit mounted on the accelerator base and extending through the column to the high voltage terminal plate. The tube consists of tube electrodes and insulators match the number and spacing of the equipotential planes in the generator column. Springs are connected between each accelerator tube electrode and the corresponding column plane, so that the voltage gradient on the column is extended to the accelerator tube. Six spark gaps (each a stainless steel hemisphere) are mounted integrally with the rim of each tube electrode. The parts are so oriented that a succession of spark gaps is formed down the tube to protect the tube against voltage surges. The accelerator tube performs two important functions: it focuses the positive ions into a beam and it accelerates them.

- (1) The acceleration of the beam is a constant because the voltage gradient in the tube is in uniform steps and is the same as the voltage gradient of the column. The acceleration energy of the particles is a product of the terminal voltage. In the case of the Model K-4000, when the generator is operated at 4 MV, the beam has an energy of 4 MeV, where an electron volt (eV) is the energy gained by a charged particle when it falls through a potential of 1 volt.
- (2) The beam is initially focused in the accelerator tube. The focus can be varied by a focus power supply which places a potential of up to -40 kV on the first working electrode of the accelerator tube. The polarity is negative with respect to the terminal.
- (3) Conditioning the Accelerator Tube -- This is a process designed to remove residual gas from within the tube structure. Gas molecules may escape into the accelerator tube whenever the internal surfaces of the tube are subjected to voltage gradients in the order of 40 kV per inch under a high vacuum condition. This process of escaping gas is known as tube "outgassing" and may be indicated by the following conditions: a slight rise in vacuum indication; no increase in generator voltage when the belt charge current is increased; and an increase in radiation (gamma rays) in the vicinity of the terminal source caused by back-streaming electrons (which are accelerated towards the source end of the accelerator tube). This effect is observed as a series of "peaks" on the scope pattern when monitoring the terminal voltage ripple.

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NOTE: The most convenient indication of outgassing is obtained by checking for peaks when monitoring the terminal voltage ripple. This is done by observing the vacuum pressure or by monitoring the gamma radiation outside the pressure tank in the vicinity of the source.

If tube sparking should occur during the conditioning period, reduce the belt-charge until sparking stops.

- (a) Whenever severe tube sparking occurs during the conditioning process, check the tank gas pressure, dew point, and carbon dioxide (CO<sub>2</sub>) content. The tank gas pressure should be approximately 275 psi, the lowest operating dew point -55 °V, and the CO<sub>2</sub> content at least 20%. Always attempt to keep the pressure tank gas as dry as possible. A dew point at least -60 °F should be maintained, 65 psig for SF<sub>6</sub> -60 °F dew point.
  - (b) Adjust the CORONA LOAD control pushbuttons until a 40 to 50  $\mu$ A indication is obtained on the CORONA LOAD meter. The accelerator should be unstabilized.
  - (c) Monitor the terminal voltage ripple. This may be accomplished by connecting a calibrated oscilloscope to the capacitive probe provided for this purpose on the side of the pressure tank.
  - (d) As the terminal ripple peaks subside, increase the belt charge until the terminal voltage is in the order of 200 kV above the desired voltage at which the accelerator will normally operate.
  - (e) The conditioning period can be greatly enhanced by applying a load of approximately 15-20  $\mu$ A of beam current at about 2 MV of terminal voltage.
  - (f) Sometimes "hard spots" will be encountered and the conditioning process will not advance for several hours. This condition is normal and will generally occur between 3.5 and 4 MeV. (Condition up to 4.25 MeV.)
  - (g) If the accelerator tube has been operating at lower than rated voltages or has been idle for extended periods of time, the conditioned level of the tube may lower. If this should occur, the accelerator tube must be re-conditioned. The re-conditioning process should take about two or three hours for a new tube, while dropping to about a half an hour as the tube ages. Careful and precise vacuum maintenance techniques will minimize conditioning time, as will proper accelerator maintenance.
- (4) Removing the Accelerator Tube

— CAUTION —

DO NOT APPLY ANY SIDE PRESSURE TO THE  
TUBE; IT IS SUPPORTED ONLY AT ITS BASE.

- 
- (a) Close both gate valves.
  - (b) Admit air into the tube through the roughing insert and a cold trap.
  - (c) Remove all the column rings and disconnect the connector springs from the tube.
  - (d) Remove the ion source assembly and blank off the accelerator tube.
  - (e) Attach the tube-lifting jig.
  - (f) With a hoist, gently raise the tube-lifting jig until the rigging is slightly taut but not taut enough to place a strain on the tube.
  - (g) Loosen the two selsyn brackets adjacent to the lower end of the tube. Swing the selsyns away from the tube to allow for working area.
  - (h) Unbolt the tube at the junction between the tube flange and the mount, leaving the mount bolted to the base. Gently push the tube towards the terminal to "break" the union with the mount.
  - (i) Swing the lower end of the tube away from the column.
  - (j) Hoist the tube away from the column. Use caution to avoid damaging the tube or the column.
  - (k) Blank off the base of the acceleration tube. Also blank off the mount opening at the accelerator base if a new tube is not going to be installed immediately.

NOTE: Record in the maintenance log the condition of the removed tube, including discoloration, internal surface tracks, column punctures, and so forth.

- (l) Inspect the tube seals for failure. Do NOT attempt to re-use a tube which contains cracks through the volume of the glass. Some chipping of edges is permissible but undesirable.
  - (m) Conditioning a new accelerator tube cannot be neglected. It is also important to condition a tube in service, whenever it seems to need conditioning. High voltage equipment should not suddenly be subjected to high voltage. Build up the voltage gradually. Particles or rough edges left from the manufacturing and handling process, as well as gases within the tube, can be burned away without damaging the equipment.
- (5) Installing the Accelerator Tube -- To install the accelerator tube, reverse the tube removal procedure.

b. Ion Source

A gas (e.g., hydrogen) is ionized within the source bottle by rf energy applied to the outer periphery of the bottle through coupling clips. Positive ions, produced by the gas ionization, are repelled from the source bottle and into the accelerator tube by a positive potential at the anode of the source bottle. This positive anode potential is remotely controlled by the BEAM CURRENT selsyn at the control console. (Refer to Figure 14.)

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NOTE: Tuning the ion source is described in  
Instruction Bulletin, HVI-1084M1.

- (1) Prior to removing an ion source, the acceleration tube must be brought up to atmospheric pressure (refer to paragraph (4), page 52).

— CAUTION —

EXERCISE CARE WHEN HANDLING THE COPPER TUBING  
GAS LINE. THE LINES ARE FRAGILE AND WILL BREAK  
IF BENT TOO OFTEN.

- (2) The components of the source canal are replaceable. (See Reference No. 1.)

c. Terminal Assembly

The terminal circuitry is such that standard troubleshooting techniques can be employed. Generally, the nature of the failure will indicate the defective component. The major components located on the terminal are described in the following paragraphs.

- (1) RF Power Supply and Exciter -- This unit generates the rf energy used to ionize the gas within the ion source. The power supply consists of a power transformer, a full-wave rectifier, and a filter network. The rf exciter consists of two tetrodes connected for push-pull operation. The exciter output is coupled to the ion source bottle by a 300-ohm twin-lead transmission line. Cooling of the exciter tubes is accomplished by two blowers mounted at the rear of the exciter assembly.
- (2) Probe Power Supply -- This unit provides a positive (with respect to the terminal plate) potential to the anode of the ion source. This positive potential collects the electrons that are stripped from the gas during ionization, while repelling the positive ions out of the source and into the accelerator tube. The power supply consists essentially of a power transformer, bridge rectifier circuit and a filter network. The power supply is controlled by the BEAM CURRENT selsyn from the control console, and is variable from 0 - 4,000 volts dc.
- (3) Focus Power Supply -- This unit provides a negative (with respect to the terminal plate) potential that is applied to the first insulated electrode of the accelerator tube. The electrostatic geometry between the electrode and the source canal collimates the positive ions within the accelerator tube into a beam. The power supply consists essentially of a power transformer, two selenium rectifiers, a filter network, and a voltage divider. The power supply is controlled by the FOCUS selsyn from the control console. The power supply output may be raised to a maximum of -40 kV (maximum of 5 kV in air).
- (4) The Gas Controls -- Two types of gas controls (leaks) are available for use with this accelerator (palladium and thermo-mechanical). Each of these is described in the following references.

- 
- (a) The Thermo-Mechanical Leak - HVI-1044
  - (b) The Palladium Leak - HVI-1013M2
  - (5) Removing the Terminal Assembly -- HVE does not furnish a special lifting tool for the accelerator terminal assembly. The assistance of another man is required to remove it.
    - (a) Remove the gas line that connects the leak manifold to the ion source. Prior to removing the gas line, bring the accelerator tube up to atmospheric pressure.
    - (b) Remove the wires between the alternator and terminal components.
    - (c) Support the terminal assembly.
    - (d) Remove the bolts which fasten the terminal support legs to the lower terminal plate and the alternator pillow block rods.
    - (e) Remove the assembly.

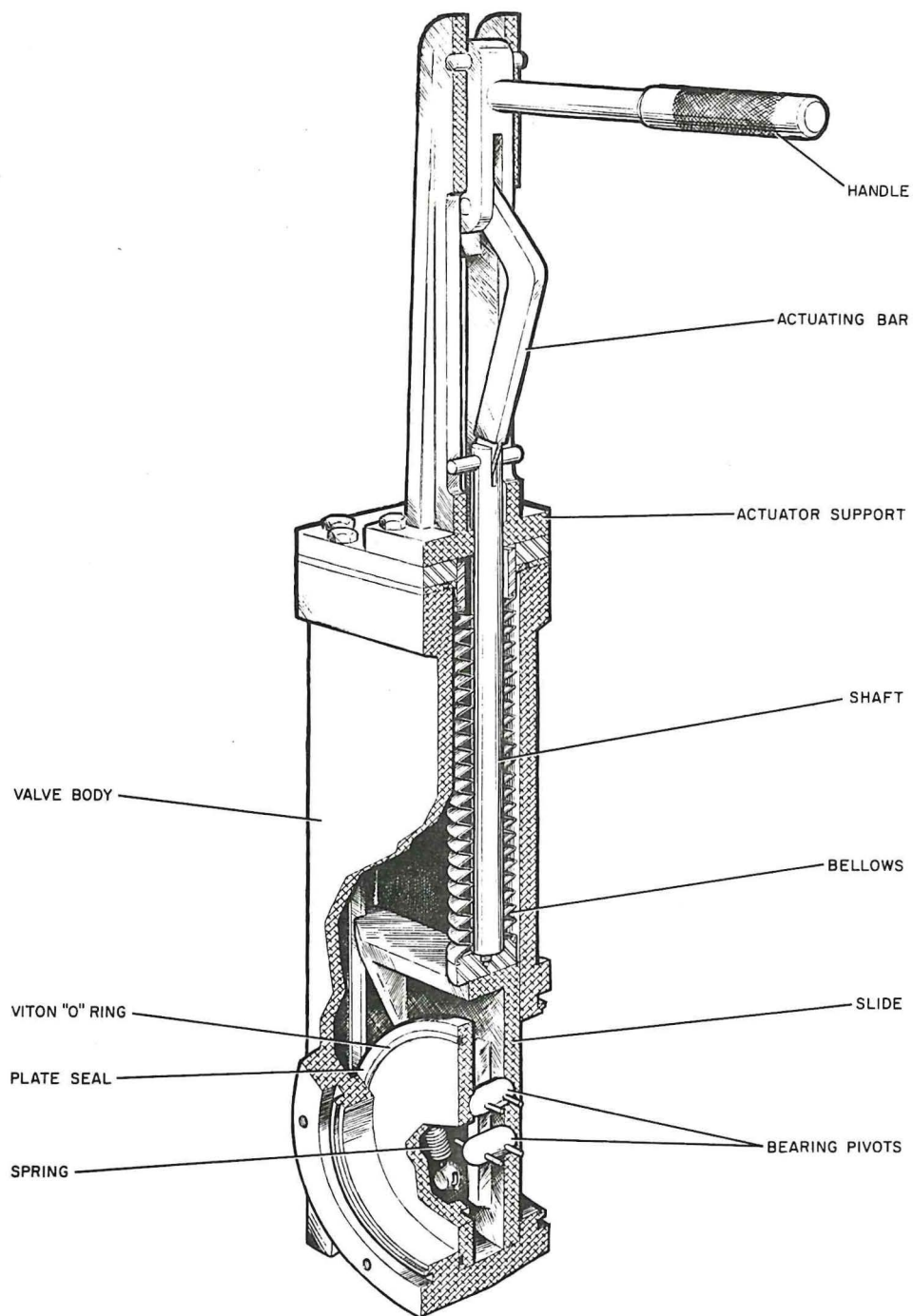
d. Tube Extension

The tube extension provides a highly evacuated path for the accelerated positive ions to travel to the target. The accessory units mounted on the extension are described in the following paragraphs.

- (1) The Beam Steerer -- This unit is located adjacent to the tank base and serves to center the beam on the target. It contains four stainless steel plates--two vertical and two horizontal. An x-axis and a y-axis potential, controlled at the control console, are adjusted to deflect the beam towards the beam centerline.
- (2) The Gate Valves -- Two gate valves are provided to isolate either the entire acceleration path, or just the tube extension, from the vacuum system. The main gate valve isolates the entire acceleration path. The auxiliary gate valve isolates just the target end of the tube extension. (Refer to Figures 15 and 16.)
- (3) The Target -- This unit varies, depending on customer requirements. To remove a target from the tube extension:
  - (a) Isolate the extension with the auxiliary gate valve, thereby maintaining a vacuum on the accelerator tube. Close the water flow to the target.
  - (b) Bring the extension up to atmospheric pressure with the roughing insert.
  - (c) Remove the target.
  - (d) After replacing the target, evacuate the tube extension with the roughing pump.

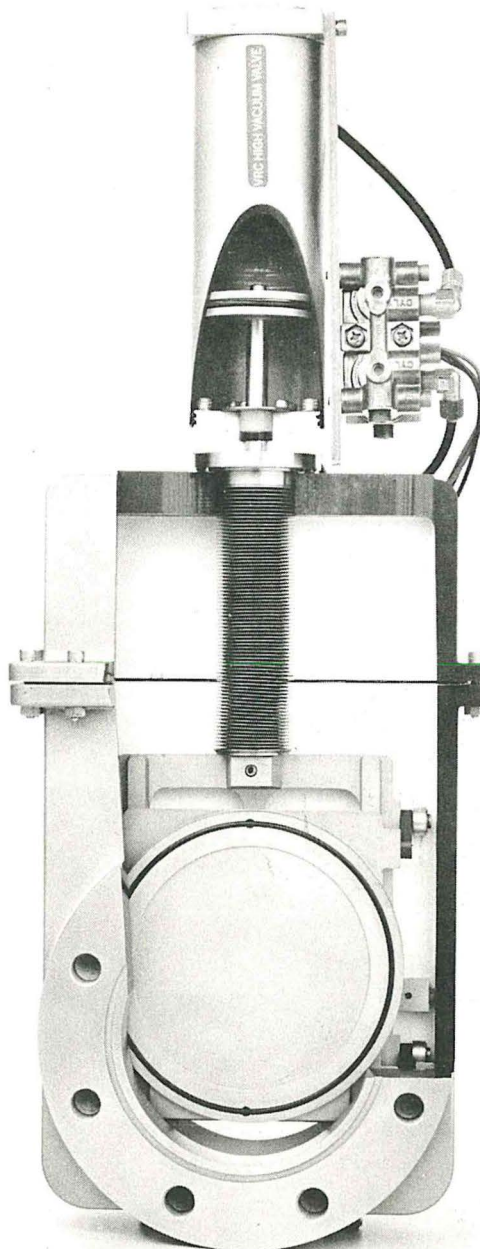
— CAUTION —

CHECK THE POSITION OF THE AUXILIARY GATE  
VALVE PRIOR TO ENERGIZING THE ACCELERATOR.



1970

FIGURE 15. GATE VALVE (4-INCH PORT)



**FIGURE 16. GATE VALVE (2-INCH PORT)**

SEALED BELLOWS DESIGN. ALSO USED FOR  
EQUIVALENT 2" MANUAL HANDWHEEL MODEL.

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## 5. VACUUM SYSTEM

The accelerator-tube system must be operated with a high vacuum (low pressure) to minimize collisions between the accelerated particles and gas molecules. The normal operating pressure of the accelerator tube system is in the order of  $6 \times 10^{-6}$  mm Hg. The maximum permissible continuous operating pressure is  $1.5 \times 10^{-5}$  mm Hg. If the pressure exceeds  $2 \times 10^{-4}$  mm Hg, the poor vacuum interlock relay will energize, applying power to the time delay relay. After a two-second time delay, the circuit to the drivemotor interlock relay will be broken, de-energizing the relay and breaking the circuit to the drivemotor. The vacuum system consists of: an oil diffusion pump, water-cooled baffle, a motor-driven fore pump, a vacuum and water junction box, a Penning (Phillips) ionization gauge, and various operating and protective circuits and devices.

### a. Oil Diffusion Pump

See Vendors' data.

#### (1) Adjustments

- (a) Thermal Switch -- The oil diffusion pump thermal switch is designed to open the diffusion pump heater circuit when the temperature of the pump reaches its maximum operating temperature. This temperature is reached when the temperature of the cooling water waste reaches 85 °F. The switch is strapped onto the cooling coils adjacent to the bottom of the pump. To adjust:
  - i. Measure the temperature of the cooling-water supply. It should not be over 65 °F, and preferably within a range of 50 °F or less.
  - ii. Check the flow of water through the diffusion pump cooling coil. It should be between 0.5 and 1 gpm.
  - iii. Operate the vacuum system as in normal operation. Allow time for the pump temperature to reach a stable value (approximately 1 hour).

#### (2) Repair Instructions

- (a) Preparation for vacuum maintenance.

#### CAUTION

AFTER REMOVING A SECTION OF THE VACUUM SYSTEM, USE BLANK-OFF FLANGES OR PAPER TO PREVENT THE ENTRY OF DIRT OR CONDENSABLE VAPORS. INSPECT, CLEAN OR REPLACE GASKETS (IF NECESSARY) WHEN MAKING REPAIRS TO THE VACUUM SYSTEM.

- i. Close the gate valve to isolate the section to be serviced.
- ii. Have the necessary tools and equipment ready before opening the vacuum system.

- 
- iii. Admit dry air to the section to be disassembled, through the cold trap on the roughing pump dolly.

(b) Heater replacement. Refer to Vendor's Data.

b. Fore Pump

A mechanical fore pump is used to remove the exhaust from the mercury diffusion pump and to discharge it to the external atmosphere. As used with the Van de Graaff Generator, the diffusion pump has an exhaust pressure limit of about  $1 \times 10^{-1}$  mm Hg.

NOTE: For further descriptive material and maintenance information, refer to the vendor data supplied with the equipment.

c. Penning Ionization Gauge

The vacuum in the accelerator tube system is monitored by a Penning (Phillips) ionization gauge. The structure, operating principle, and circuit description of the Penning gauge are as follows:

- (1) Structurally, the gauge consists of an anode and a cathode contained within a metal envelope.
- (2) The metal envelope is connected to the accelerator tube system through a take-off located in the tube extension adjacent to the take-off for the vacuum pump.
- (3) The anode is connected to the positive output of a dc power supply, through a set of limiting resistors.
- (4) The cathode of the gauge is grounded.
- (5) A permanent magnet, which is an integral part of the gauge, introduces a magnetic field to the electron flow. The magnet increases the length of the electron path. Thus, the probability of ionizing residual gas molecules is greatly enhanced. A discharge may then be generated at exceedingly low pressures.
- (6) A meter loop is connected from ground through the relays and through the secondary of transformer T6B01.
- (7) As the pressure in the envelope of the Penning gauge increases, conduction in the power supply increases and the meter indication increases.

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NOTE: For maintenance information, see  
HVI-1045M1, referenced in the Table of  
Contents.

d. Producing a Vacuum

The vacuum system extends through three sections: the vacuum pump system, the accelerator tube, and the accelerator tube extension. These sections are separated by gate valves. The vacuum pumping system, after being evacuated to a low pressure, is connected to the other two sections which have been previously roughed out. To produce a vacuum:

- (1) Close the air inlet valve.
- (2) Open the gate valves separating the three sections.
- (3) Open the fore line valve.
- (4) Rough out the system with the roughing pump.
- (5) Start the fore pump and shut off the roughing pump.
- (6) Turn on the diffusion-pump cooling water. There should be approximately one gpm flow through the diffusion pump and the baffle. The cooling water coils on the pump and baffle are connected in series.
- (7) Energize the diffusion pump heater. The DIFFUSION PUMP switch is on the same panel as the FORE PUMP switch. The DIFFUSION PUMP lamp will light if the fore pressure is low enough and if the cooling water is cool enough.
- (8) The final vacuum should be between  $1 \times 10^{-6}$  and  $3 \times 10^{-5}$  mm Hg.
- (9) The POOR VACUUM lamp will light between pressures of 23 inches Hg and  $2 \times 10^{-4}$  mm Hg.
- (10) The GOOD VACUUM lamp will light and the vacuum gauge will be energized at  $2 \times 10^{-4}$  mm Hg or better.

6. WATER COOLING SYSTEM

Cooling water is distributed (in a closed circuit) from a water chiller to the generator tank cooling fins. Cooling of other components such as the magnet coils, analyzing chamber, focusing ring, slits, viewers, and targets, is accomplished with city water obtained from the main water supply. The water chiller closed circuit retains its water permanently, by means of a reservoir, and is circulated by pumps. The water is drained only for cleaning purposes and permanent shutdown. Further information on the chiller, including installation, operation and maintenance, is contained in the vendor data.

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NOTES: Chiller instruction bulleting should be considered as part of these instructions and must be read before operating the equipment.

The chiller is composed of standard commercial refrigeration components and should be serviced by TRAINED refrigeration personnel.